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Guide to Resource Conservation and Cost Savings Opportunities in the Dairy Processing Sector

Ministry of Environment and Energy

Ontario

Guide to Resource Conservation and Cost Savings Opportunities in the Dairy Processing Sector

September 1995

© Queen's Printer for Ontario
ISBN 0-7778-4625-X
PIBS 3368

PRINTED ON RECYCLED PAPER
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500 - 09/95

Ministry of Environment and Energy

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September, 1995

Dear Reader:

The Ontario Ministry of Environment and Energy and the Ontario Dairy Council are pleased to provide this copy of the *Guide to Resource Conservation and Cost Savings Opportunities in the Dairy Processing Sector*. The guide was prepared jointly by the ministry and the council, with support from the Ontario Ministry of Agriculture, Food and Rural Affairs, as well as Natural Resources Canada.

This guide identifies and promotes opportunities for conserving energy and water, as well as reducing waste, in the dairy processing sector. By taking advantage of these opportunities, operators can lower their costs while conserving valuable resources.

A wide range of groups have an interest in further refining dairy processing techniques, including dairy owners, managers and employees; entrepreneurs; product and technology suppliers; engineering designers; and consultants. By combining their own knowledge and skills with the information contained in this guide, these groups can help keep the Ontario dairy processing sector competitive by becoming more efficient and conserving valuable resources.

We hope this guide is useful to you and/or your company or organization. We would be grateful to receive any comments or questions you may have about this publication. A form is enclosed so that you can send comments by fax or mail.

You may also contact the Ontario Dairy Council at (905) 542-3620 and the Industry Conservation Branch of the Ministry of Environment and Energy at (416) 327-1439.

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Ontario

EXECUTIVE SUMMARY

Purpose of Guide

The "Guide to Resource Conservation and Cost Savings Opportunities in the Dairy Processing Sector" was prepared to help those involved in dairy products manufacturing to identify potential process improvements that will reduce production costs and conserve resources. The guide is intended to be a helpful tool that can be used in combination with existing skills and knowledge among clients who share an interest in the dairy processing sector. Individuals and client groups interested in this guide could include dairy owners, managers, employees, product and technology suppliers, engineering designers, consultants and related associations.

The guide offers a series of generic process descriptions and checklists of improvement opportunities specific to each of six major processes used in dairy processing. The six major processes are:

- Fluid milk;
- Cheese;
- Ice Cream and frozen products;
- Cultured products (e.g. yoghurt);
- Butter; and
- Evaporated/dried products.

Contents of Guide

The information that is featured in this guide is outlined as follows:

Chapter 1, "Introduction", outlines the purpose of the guide and the intended target audience.

Chapter 2, "Sector Profile", outlines a context for exploring resources conservation and cost savings opportunities in Ontario's dairy processing sector. It provides a "snapshot" of the sector and includes summaries of a number of key variables such as the current number and size of plants, economic status, product trends, relevant regulations and emerging issues in the sector.

Chapter 3, "Products and Generic Processes", outlines the rationale as well as the generic processes selected for careful examination of resource conservation and cost savings opportunities. Limitations of the generic approach adopted for this guide are also described.

Chapter 4, "Resources Utilization", described the wide range of energy, water and material resources that are commonly used in relation to the various generic processes.

Chapter 5, "Process Residuals", describes the air, water and solid waste residuals that are commonly derived from the various generic processes.

Chapter 6, "Generic Process and Utility Descriptions", outlines generic process descriptions as well as the typical utility and service demands for dairy processing plants.

Chapter 7, "Generic Process Improvement Opportunities", provides concise generic checklists to assist in identifying process related improvement opportunities incorporating energy/water efficiency and pollution prevention. Each tabulated checklist summary identifies thermal, electrical, environmental and water use implication, low cost/no cost measures that can be implemented, retrofit technology options and general comments.

Chapter 8, "New Technologies", identifies and describes a variety of new technologies that may exhibit future potential to apply to the processing of dairy products.

Chapter 9, "Other Helpful Information for Dairy Processors", outlines a variety of means for assessing the performance of dairy plants. Potential generic heat recovery and process retrofit opportunities are described on the basis of average retrofit payback periods. A variety of other important references are also provided such as case studies, product knowledge reference guides and pollution prevention guidance documents.

How to Use This Guide

Guidance on "how to use this guide" is provided in the next two tables. Starting points in the text (i.e. page numbers for key figures/tables/sections) are identified for the reader who wishes to proceed directly to specific areas of interest. Probable areas of interest such as process descriptions for each of the six generic processes, new technologies and sources of additional information are included.

SUMMARY OF STARTING POINTS FOR PROCESSES

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Cheese	Figure 6.2 on page 52/53
Ice Cream and Frozen Products	Figure 6.3 on page 54/55
Cultured Products	Figure 6.4 on page 56/57
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Evaporated/Dried Products	Figure 6.6 on page 60/61

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Water	Section 4.2 on page 25
Materials	Section 4.3 on page 27
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Sector Profile	Section 2.0 on page 3

Obtaining Additional Copies

Additional copies of the "Guide to Resources Conservation and Cost Savings Opportunities in the Dairy Processing Sector" are available through the ministry's Public Information Centre, 135 St. Clair Avenue West, Toronto, Ontario, M4V 1P5. The centre is open Monday through Friday from 9:00 a.m. to 4:30 p.m.

Or call:	Outside Toronto	1-800-565-4923
	in Toronto Area	416-323-4321

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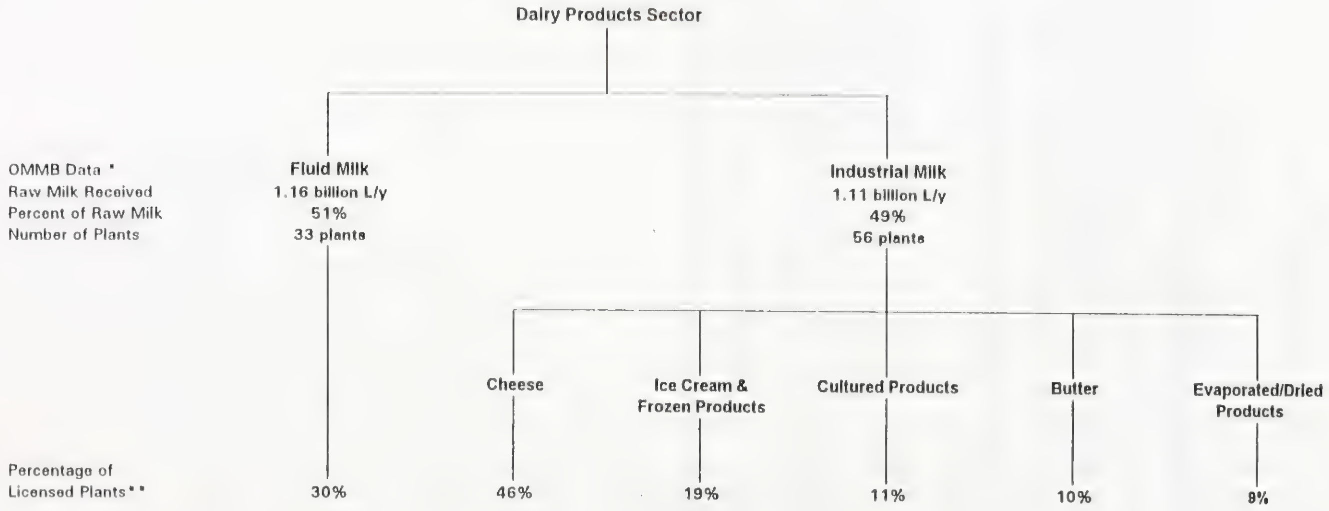
1.0 INTRODUCTION

Dairy processing involves the preparation of milk, typically from cows, and milk-derived products for human consumption. It represents an important component of the food and beverage industry in Ontario. The dairy products sector was selected by the Industry Conservation Branch of the Ontario Ministry of Environment and Energy (MOEE) for a sector specific assessment, as summarized in this guide, to highlight opportunities for energy and water efficiency improvement, resource conservation, and reduction of environmental releases at source.

The purpose of this guide is to encourage those who play a role in manufacturing processes to consider and, where appropriate, implement process refinements in order to conserve resources and minimize production costs. The audience for this guide includes all stakeholders in the manufacturing processes. These include dairy owners, managers, employees, entrepreneurs, product/technology suppliers, designers, consultants and related associations.

FIGURE 2.1: Dairy Products Sector Characterization



Notes:
* Data derived from Ontario Milk Marketing Board. Dairy Statistical Handbook 1993-94. Table 59.
** Plants involved with major processes. Percentages will add to more than 100%.because of overlap.

2.0 SECTOR PROFILE

A brief profile of the dairy products sector is presented in the following sections.

2.1 Sector Activities

The dairy processing industry in Ontario is comprised of a range of companies involved in the manufacture of dairy products. Establishments in the processing industry are traditionally divided into two separate categories, fluid milk and industrial milk:

- Fluid milk processing involves the pasteurization and processing of liquid milk for direct consumption, as well as creams, chocolate and other flavoured milks, and buttermilk (Canadian SIC 1041).

- Industrial milk processing involves the processing of milk into value-added products. These include cheese, butter, ice cream and other frozen products, condensed and evaporated milk, dried milk powder, yoghurt and other cultured milk products (Canadian SIC 1049). The milk used in the manufacture of industrial milk products is also pasteurized before processing.

The distinction between these two categories has important regulatory implications and is also important in terms of the types of processes involved and the resulting environmental effects. A breakdown of the sector according to these major categories and associated subcategories of products is presented in Figure 2.1. The numbers of plants and associated milk volumes for fluid and industrial categories in 1993/94 are also presented in Figure 2.1.

For the purpose of this guide, six major separate process sequences have been considered. These processes, which are presented in Figure 2.1, are:

- Fluid milk;
- Cheese;
- Ice cream and other frozen products;
- Cultured products;
- Butter; and
- Evaporated/dried products.

The approximate percentages of all currently licensed dairy processing operations in Ontario having some involvement in the production of these individual major products are indicated in Figure 2.1. A more detailed listing of all licensed plants in Ontario, broken down by the product mix as shown above, is presented in Appendix A.

2.2 Number and Sizes of Plants

Agriculture and Agri-Food Canada lists a total of 137 plants in Ontario licensed to handle dairy products, although not all may be presently operating or receiving direct shipments of raw milk.[1] According to data from the Ontario Milk Marketing Board (OMMB), as outlined in Figure 2.1 and Table 2-1, there are currently 89 licensed plants in Ontario receiving raw milk. Approximately one-third are fluid milk plants and two-thirds are industrial milk plants.[2]

Over the past five years there has been a reduction in the number of dairy processing plants in Ontario, reflecting a national trend toward consolidation of the dairy industry. The 18% decrease in Ontario plants over the past five years has been reflected almost equally in both fluid and industrial operations.

---

[1] Agriculture and Agri-Food Canada. Canada Dairy Listing as of March, 1994.

[2] Note that data provided by OMMB is only subdivided by the major categories (SIC) of fluid and industrial milk. Data is not subdivided further for industrial products into process subcategories.

Plant operations can be divided into three broad categories according to approximate size:

- Large plants, receiving more than 50,000,000 Litres of raw milk annually.
- Medium plants, receiving 10,000,000 to 50,000,000 Litres of raw milk annually.
- Small plants, receiving less than 10,000,000 Litres of raw milk annually.

The current distribution of plants by size is presented in Table 2-1. The distribution of fluid milk plants by size category is fairly even, while there is a much higher proportion of small industrial operations, reflecting primarily smaller cheese production plants. The largest decline in the numbers of plants over the past 5 years in Ontario has been for smaller plants, again reflecting a trend towards consolidation and economies of scale.

TABLE 2-1
DISTRIBUTION OF PLANTS BY SIZE IN ONTARIO IN 1993/94[3]

PLANT SIZE	FLUID MILK (SIC 1041)	INDUSTRIAL MILK (SIC 1049)	TOTAL
Small Plants (< 10 mil Litres)	13 (39% of Fluid)	28 (50% of Industrial)	41 (46% of Total)
Medium Plants (10-50 mil Litres)	12 (36% of Fluid)	25 (44% of Industrial)	37 (42% of Total)
Large Plants (> 50 mil Litres)	8 (24% of Fluid)	3 (5% of Industrial)	11 (12% of Total)
TOTAL PLANTS	33	56	89

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[3] Ontario Milk Marketing Board. Dairy Statistical Handbook 1993-94. Tables 59-61. Breakdown of data from OMMB on plant size is only available for major categories of fluid and industrial, not subcategories of processes/products.

2.3 Current Economic Status

Dairy processing is an important component of the food and beverage industry in Ontario. Economic figures for 1992 from Statistics Canada, as summarized in Table 2-2, show that this sector represents approximately:

- 13% of the value of food and beverage industry shipments in Ontario ($2.5 billion);
- 9% of food and beverage industry employment in Ontario; and
- 11% of all food and beverage industry establishments in Ontario.

TABLE 2-2
ECONOMIC SUMMARY OF DAIRY PROCESSING SECTOR IN ONTARIO 1992[4]

GROUP NAME (CAN SIC)	VALUE OF SHIPMENTS[5] ($)	EMPLOYEES (NUMBER)	ESTABLISHMENTS (NUMBER)
Fluid Milk Processing SIC 1041	$1,179,700,000 (6% of Total)	2,140 (4% of Total)	38 (4% of Total)
Industrial Milk Processing SIC 1049	$1,364,300,000 (7% of Total)	3,161 (5% of Total)	67 (7% of Total)
Total Food & Beverage SIC (10 & 11)	$18,755,500,000	60,645	984

While the dairy processing sector is a large and important industry, it has generally involved high product volumes with relatively low profit margins on products. As a result, the industry has exhibited limited profitability, limiting the extent and potential for capital investments.

---

[4] Data from Statistics Canada for 1992.

[5] Value of Shipments of Goods Own Manufacture Only.

Despite both the relatively low profit margins in dairy processing and the trends toward consolidation, there has still been substantial investment in dairy facilities in Ontario. In 1990, based on data from Industry Canada, dairy plant investments in Canada totalled almost $160 million nationally.[6] A significant element of investment has been in product and technology research. Beginning in 1987, chairs in dairy research at the University of Guelph have been sponsored by the Ontario Dairy Council and the Ontario Milk Marketing Board.

2.4 Dairy Product Trends

Throughputs of milk and milk products are well documented. The total volume of milk received annually by dairy processing plants in Ontario, both fluid and industrial, has remained relatively static over the past five year period. Approximately 2.3 billion Litres of raw milk was received during 1993/94.[7]

Sales volumes of dairy products over the past five years have also remained similarly stable, with some notable exceptions, as follows:[8]

- Trend in consumer preference toward consumption of lower fat content fluid milk. The 1% butter fat milk product was introduced into Ontario in 1990.
- General decline of approximately 10% in consumption of all types of cheese.
- Occasional volatility with regard to yoghurt and skim milk powder products.

---

[6] Industry, Science and Technology Canada. 1991. Sector Profile: Dairy Products.

[7] Ontario Milk Marketing Board. Dairy Statistical Handbook 1993-94. Table 59.

[8] Ontario Milk Marketing Board. Dairy Statistical Handbook 1993-94. Table 57-58.

FIGURE 2.2: Trends in Ontario Fluid Milk Sales from 1984 to 1993

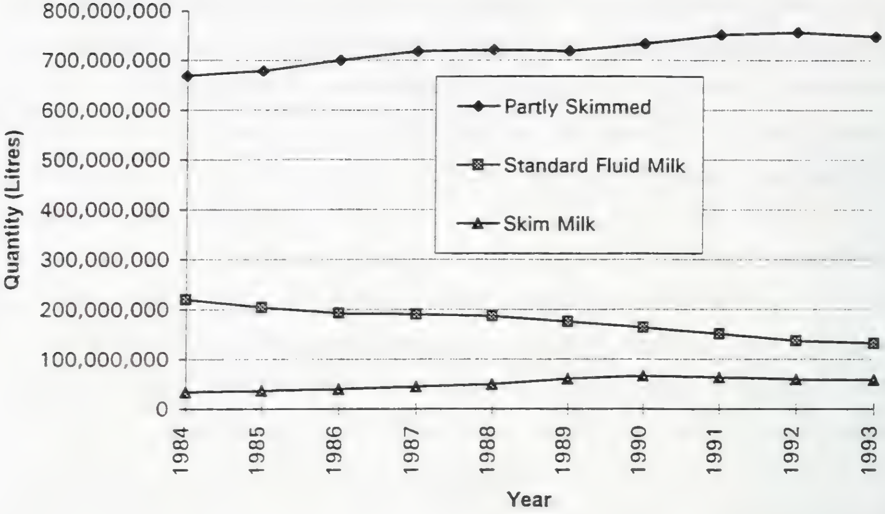
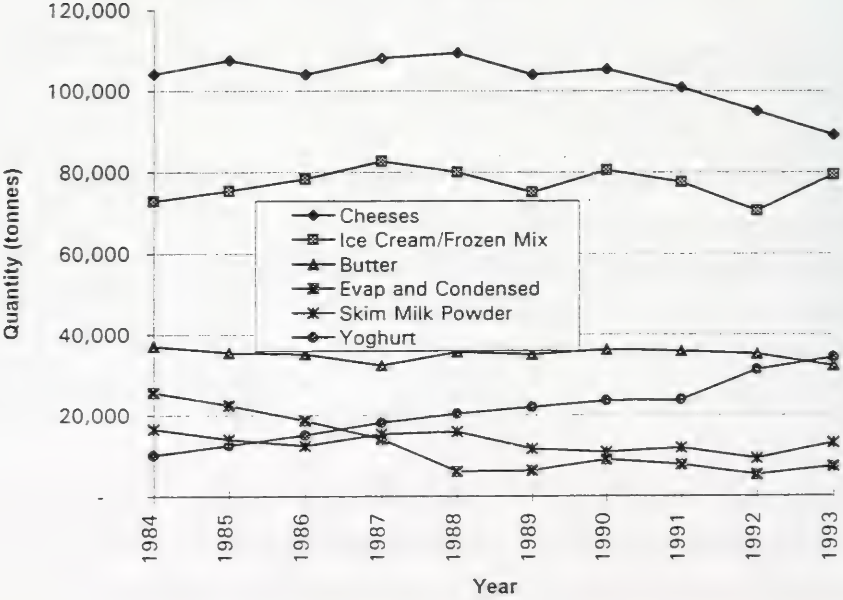


FIGURE 2.3: Trends in Ontario Industrial Product Sales from 1984 to 1993



Trends in fluid milk and industrial milk products over the past decade are summarized in Figures 2.2 and 2.3 respectively.[9] While total milk volume receipts and sales have remained relatively constant, per capita consumption of fluid milk has declined significantly (~13%) and steadily over the past 10 years. In 1993/94 annual per capita consumption in Ontario was 90 Litres, compared with 104 Litres in 1983/84.[10]

New product sale trends reflect the low fat-content desire of consumers and challenge the dairy industry to offer variety and new "twists" on mature products. One of the fastest growing products is low-fat cheese. Niche marketing of products such as kefir and tzatziki is on the increase. Marketers have also tried to reawakening interest in mature fluid milk by introducing new processing techniques. Dairy processors are also increasing their marketing of higher fat content cheese, butter and cream in an attempt to maintain market share for these products. Competition from alternates to bovine milk, such a soy beverages and goat milk, also appears to be increasing. Changes in consumer demands will continue to impact dairy plant operations.

2.5 Regulation

Dairy products processing in Canada is highly regulated. The most important areas are:

- Milk supply management;
- Food quality and food safety; and
- Environmental discharges.

Each of these regulatory areas is discussed in the following sections, and an overview summary of relevant regulations is presented in Table 2-3.

---

[9] Ontario Ministry of Agriculture Food and Rural Affairs. 1993. Agricultural Statistics for Ontario. Section 8.

[10] Ontario Milk Marketing Board. Dairy Statistical Handbook 1993-94. Table 65.

TABLE 2-3
SUMMARY OF REGULATIONS RELEVANT TO THE DAIRY PROCESSING SECTOR

CATEGORY		LEGISLATION, REGULATION, GUIDELINE	FED OR PROV	ADMINISTERING AGENCY	RELEVANT ASPECTS
Primary Products		Milk Act Ontario	Provincial	OMAFRA	Supply management and food safety
		Dairy Plant Regulated Inspection System (DPRIS)	Joint	AFFC/OMAFRA	Food safety of plant processes
		Food and Drug Act	Federal	HC	Proper labelling of food ingredients. Indirectly affects use of recycled plastics.
		Health Protection and Promotion Act	Provincial	MOH	Maintenance of health at point of sale.
Notification		Environmental Bill of Rights	Provincial	MOEE	Public notification
All Potential Discharges		Certificate of Approval	Provincial	MOEE	Control of plant discharges
Effluent	Direct	Fisheries Act	Federal	MOEE	Control of direct discharges to receiving bodies of water
		Ontario Water Resources Act	Provincial	MOEE	Control of direct discharges to receiving bodies of water
		Environmental Protection Act	Provincial	MOEE	Control of direct discharges to receiving bodies of water
		Environmental Protection Act Regulation 358	Provincial	MOEE	Control of sewage systems
	Municipal	Municipal Act	Provincial	Municipalities	Authority for By-Laws to control municipal sanitary sewer discharges
Air	Particulates	Regulation 346	Provincial	MOEE	Control of emissions. Relevant to dryers.
	Odours	Environmental Protection Act	Provincial	MOEE	Control of odours
Solid Waste	General	Regulation 102/94	Provincial	MOEE	Waste auditing and reduction
		Regulation 103/95	Provincial	MOEE	Source segregation of wastes
	Packaging	National Packaging Protocol	Interprovincial	CCME	Packaging reductions
		Regulation 104/94	Provincial	MOEE	Package auditing and reduction
		Regulation 344 and 345	Provincial	MOEE	Control of milk container materials
Animal Feed	Direct	Health of Animals Act	Federal	AAFC	Registration of "garbage feeders", processing requirements
(for by-products)	With Processing	Canada Food Act	Federal	AAFC	Producer registration , labelling etc.
Land Application	All Methods	Regulation 347	Provincial	MOEE	Specify application sites, timing of application , incorporation into soil and testing and monitoring.
	Ag Lands	Interim Guideline for Utilization of Waste (Other than Sewage Sludge)	Provincial	MOEE/OMAFRA	Procedural requirements, qualtiy criteria, site criteria, and handling and spreading.
Composting		Environmental Protection Act	Provincial	MOEE	Control of activity and potential impacts of composting operation
		Ontario Water Resources Act	Provincial	MOEE	
		Environmental Assessment Act	Provincial	MOEE	
Wastes	General	Environmental Protection Act Regulation 347	Provincial	MOEE	Control of waste management, hazardous wastes and industrial wastes

2.5.1 Supply Management

The national milk supply management system was introduced as a means to stabilize the market for non-fluid processed dairy products. It was established to provide a balance between the supply of milk and the demand for dairy products, and to reduce the cyclical periods of shortages and oversupply. It was also implemented as a way to provide price stability and protect the industry from imports.

The amount of milk that is allowed to be produced under the national milk supply management system is referred to as Market Share Quota or MSQ. The national MSQ was distributed amongst provinces based on historic shares of the industrial milk market. Ontario is allowed to produce 31% of the national total as its share of the national milk supply management system. Quebec is entitled to produce approximately 48% of the national total.

In Ontario, the marketing system is administered at two levels, fluid and industrial, under the Ontario Milk Marketing Board (OMMB). For industrial milk, the OMMB allocates quotas to both producers and processors to match the volume that is permitted under the national milk supply management system. Fluid milk is not covered under the national milk supply management system and is directly under provincial jurisdiction through the Ontario Milk Marketing Board. Under present arrangements, the interprovincial movement of fluid milk products is not allowed. There is no restriction on the interprovincial movement of industrial milk products, such as cheese.

On a national basis, approximately one-third of the total milk volume is directed to fluid milk operations, with the remaining two-thirds to industrial uses. In Ontario a different trend is evident, with approximately half of all milk to fluid and half to industrial. The reason for the difference is the result of the historical allocation of the national Market Share Quota.

With only 31% of the milk supply, Ontario dairies have been somewhat more oriented towards fluid milk operations to supply the proportionately larger population in this province, while operations in Quebec have been more oriented to industrial operations, particularly cheese. While a general movement of cheese products from Quebec to Ontario exists, precise estimates of quantities are not available.

In addition to supply management quotas and interprovincial restrictions, additional limitations also exist within Ontario. Under the Ontario Milk Act, the movement of fluid milk between Southern and Northern Ontario is not permitted.

Changes are currently underway to the current national milk supply management system to comply with the General Agreement on Tariffs and Trade (GATT) and the North American Free Trade Agreement (NAFTA). These changes will have impacts on the nature of dairy plant operations in Ontario.

2.5.2 Food Quality and Food Safety

The second important element of regulation is food safety, although food safety review procedures for the dairy industry are also currently undergoing change. Milk is a highly nutritional food product. It can also provide an ideal medium to propagate micro-organisms, including those that may be undesirable or even pathogenic.

Regulatory food safety measures serve to ensure that milk products are always acceptable for human consumption, especially with respect to microbiological content. General food safety requirements for milk include:

- Thermal pasteurization to ensure the inactivation/destruction of potentially pathogenic organisms;

- Maintenance of sanitary conditions throughout dairy plant operations to ensure that milk products do not become contaminated; and

- Appropriate packaging and storage of finished products.

Dairy plants are affected by federal, provincial and some municipal regulations related to health and food safety. The licensing of all dairy plants within Ontario through OMAFRA, in part, is for food safety assurance. In addition, any plant shipping milk products interprovincially, at present only industrial products, must be registered with Agriculture and Agri-Food Canada.

Within Ontario, the complexity of food safety regulation is being addressed through a unique Memorandum of Understanding (MOU) between the Federal and Provincial governments. Agriculture and Agri-Food Canada and OMAFRA have agreed to divide inspection responsibilities for dairy plants, and to use a common inspection form and procedure.

The nature of regulation with regard to food safety is also undergoing significant change. Regulation in the past had been oriented to inspection of final products. The Dairy Plant Regulated Inspection System (DPRIS) was implemented approximately 4 years ago and involves inspection, although more with regard to facility and process conditions. By 1996 it is expected that food safety activities will move to the voluntary implementation of Hazard Analysis and Critical Control Points (HACCP). This involves self-auditing of processes, especially at specific points deemed to be critical for maintenance of food safety.

2.5.3 Environmental

The third important element of regulation is environmental. These regulations are described in the following sections relating to air, water, solid and liquid wastes, and specific chemicals of concern.

Air

Air emission regulations can be important for dairy processing plants depending on the nature of the process. Particulate emissions result from milk product and whey drying operations. Such emissions are significant from a compliance perspective, as they fall directly under the requirements of Regulation 346 of the Ontario *Environmental Protection Act*. Installations, such as cooling towers, which generate air emissions, require a Certificate of Approval from the MOEE for operation. Another potential air impact is odour, which is also covered under the Ontario *Environmental Protection Act*. There is a potential for concern if objectionable odours are present from processing or waste treatment activities.

Water

Dairy processing plants are significant generators of liquid effluents. The nature of the regulations applied depend on whether the plant:

- Discharges to a municipal sewer system or sewage works, as regulated by the responsible Municipality; or

- Does not discharge to a municipal sewer system. This latter case may involve either direct discharge to a surface water receiving stream or body after on-site treatment in a Private Sewage Treatment (PST) system, or other options including discharge to an on-site septic field, land spreading, or off-site hauling.

For direct dischargers, a PST system is regulated directly by the Ontario Ministry of Environment and Energy, primarily under the authority of the *Environmental Protection Act*, and the *Ontario Water Resources Act*. In the case of direct dischargers, an assessment of the receiving body is undertaken, and appropriate discharge limits established based on condition of the receiving stream.

Direct discharge limit values are public, however, this data is maintained by the various District offices of MOEE, and no aggregate data is currently available for the province. Direct dischargers are not permitted to exceed the designated limits.

Small plants incorporating an on-site sewage system without discharge to surface water, such as a septic field or a proprietary aerobic system, fall under Part VIII of the *Environmental Protection Act* and are subject to Regulation 358. Such small systems are typically regulated by the MOEE District Offices. In certain municipalities inspection of routine systems may be handled by local District Health Units.

Dischargers to municipal sewer systems are subject to municipal sewer by-laws, which are enacted under the authority of the *Ontario Municipal Act*. The by-laws set limits for relevant effluent parameters. Although some differences exist between individual by-laws, most tend to follow the structure and limit values as recommended under the MOEE's Model Sewer Use By-Law.[11] These values are summarized in Table 2-4.

TABLE 2-4
MODEL SEWER USE BY-LAW LIMITS

PARAMETER	LIMIT VALUE	CITATION[12]
Biological Oxygen Demand (BOD)	300 mg/L	2.2 (i)
Total Suspended Solids (TSS)	350 mg/L	2.2 (j)
Fats, Oils and Grease (FOG)	150 mg/L	2.2 (h)
Phosphorus	10 mg/L	2.2 (k)
Nitrogen	100 mg/L	2.2 (l)
pH	5.5 to 9.5	2.2 (f)

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[11] Ontario Ministry of Environment. 1988. Model Sewer Use By-Law. ISBN 0-7729-4419-9.

[12] Ontario Ministry of Environment. 1988. Model Sewer Use By-Law. ISBN 0-7729-4419-9.

For effluent discharges to sanitary sewers where parameter values exceed municipal by-law limits, a surcharge is often applied, under a negotiated surcharge agreement. The nature of surcharges varies between municipalities, both in terms of surchargeable parameters and associated charge formulas. A surcharge agreement, for example, is not typically allowed for pH exceedance.

As described later under the Section 5.3 describing effluent residuals, biological oxygen demand (BOD) is typically the largest parameter and is also typically the largest excess parameter surcharged. As a result, municipalities tend to focus on BOD monitoring at dairy processing plants.

Solid and Liquid Wastes

The most important component of solid waste for dairy processing plants relates to packaging. The National Packaging Protocol (NAPP) was adopted in 1990 by the Canadian Council of Ministers of the Environment (CCME). The NAPP calls for the quantity of packaging sent for disposal in the year 2000 to be no more than 50% of the amount sent for disposal in 1988. The dairy products industry has been supportive of the NAPP.

Within Ontario. Regulations 102/94, 103/94 and 104/94 recently came into effect under the *Environmental Protection Act*. These regulations are usually referred to as the "3Rs Regulations". They require industrial establishments to conduct source segregation of materials. to conduct waste and packaging audits, and to develop workplans for reductions. The intent of these solid waste regulations is to help achieve Ontario's overall 50% waste reduction target, as well as to contribute to the NAPP reduction goal. Other regulations under the *Environmental Protection Act*, specifically Regulation 344 and Regulation 345, limit the nature of materials that can be used for milk containers.

Other liquid and solid wastes, such as whey if it is disposed, or sludges, are also regulated, as outlined in Table 2-3.

Chemicals of Concern

Although dairy processing plants are not generally associated with hazardous wastes, a number of chemicals of concern are used. In 1993, Environment Canada initiated a computerized inventory system, called the National Pollutant Release Inventory (NPRI), to document the annual use quantities and potential releases to the environment by industries of 178 specified substances. The intent of this inventory is to both measure current potential releases and encourage reduction in the use of these chemicals.

Facilities meeting certain minimum requirements of plant size, annual use of a specified chemical and minimum concentration of a specified chemical, are required to report the annual quantities of the chemical used, and the estimated disposal/release of the chemical. The concept and form of the NPRI system are based largely on the mandatory computerized reporting system called the Toxic Release Inventory (TRI), which has been operated in the U.S. since 1986 by the U.S. EPA.

Annual reporting data for the TRI has been compiled from 1987 through to 1992. During this time, approximately 5,400 annual reports of chemical use by dairy processing plants were recorded.[15] It is important to note that this number is very small compared to the total number of reports by other industries. More than 80% of the reports by dairy processing plants cover the use of four chemicals, summarized as follows in order of priority:

- Phosphoric acid (1,930 reports);
- Ammonia (930 reports);
- Nitric acid (910 reports); and
- Sodium hydroxide, or caustic soda (710 reports).

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[15] United States Environmental Protection Agency. 1994. 1987-1992 Toxic Release Inventory CD-ROM. EPA 749/C-94-001.

Under Environment Canada's initial list of chemicals for the NPRI, only three of these chemicals must be reported: phosphoric acid; ammonia; and nitric acid. The first NPRI annual report, for 1993, includes 2 reports in total from dairy processing plants: a report from one plant regarding the use of phosphoric acid; and a report form a second plant regarding the use of ammonia.[14]

2.6 Environmental Improvement Successes

The dairy processing sector has undertaken significant initiatives to improve environmental practices. This has both cost reduction and waste reduction implications. Processors actively work with the MOEE, OMAFRA, suppliers, and the industry on environmental issues. At the plant level there have been a range of initiatives. These include the following:

- Source separation of boxboard, steel, fine paper, glass, and corrugated cardboard.
- Conversion or improvement of refrigeration equipment to ensure it is less harmful to the environment and uses less energy.
- Installation of state-of-the-art effluent treatment programs, for pretreatment of waste prior to discharge.
- Reclamation of fat and other solids from dairy waste water.
- Recovery of water from processing systems.
- Ultrafiltration processes for product concentration (up to 50% less energy).
- Utilization of manufacturing by-products for agricultural purposes.

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[14] Environment Canada. 1994. National Pollutant Release Inventory Database v1.0 (for 1993).

2.7 Emerging Sector Issues

Over the next few years the dairy processing industry will be dealing with a number of issues. In general terms some of the major emerging issues that will need to be faced include:

- Meeting GATT/NAFTA requirements.
- Maintaining and improving competitiveness both within and outside provincial/federal borders.
- Meeting the requirements for HACCP by October 1996.
- Responding to the marketplace in a faster more efficient manner.
- Keeping pace with technology to meet health and safety and consumer demand requirements.
- Responding to environmental concerns in a cost-effective manner (emerging issues in this area to be discussed in more detail in the Resource Utilization Overview Section).
- Keeping pace with the training needs of the workforce.
- Maintaining research and development as a priority for the future.

Three specific issues of concern regarding effluent discharges are summarized as follows:

- For direct dischargers, concerns have been raised regarding apparent wide variability of BOD limits imposed, especially relative to municipal limits, and apparent variability of enforcement of limits.

- For municipal dischargers, a concern has been raised regarding the apparent slow nature of municipalities in acknowledging improvement in effluents through corresponding reductions of surcharges.

- There may also be a need for an improved protocol for BOD determination at fluid milk plants discharging to municipal systems, where an apparent imbalance of BOD may exist. This potential imbalance is discussed further in Appendix F.

3.0 PRODUCTS AND GENERIC PROCESSES

For the purpose of this guide, six major separate process sequences have been considered:

- Fluid milk;
- Cheese, including whey handling;
- Ice cream, and other frozen products;
- Cultured products;
- Butter; and
- Evaporated/dried products.

The reasons for selecting these generic process/product combinations are as follows:

- Cover the wide range of product manufacturing activities undertaken in dairy processing plants.
- Represent the natural groupings of similar generic processes, which exhibit similar resource and environmental residual concerns.
- Coincide with the general process categories that are now being separately modelled in support of HACCP.

Certain limitations must be recognized for a generic approach. These include the following:

- A generic approach assumes a high degree of homogeneity between and among manufacturing processes and resource consumption patterns of different plant operations within a specific sector. Variability, however, occurs between plants, even those that are producing the same products using the same basic processes.

- A generic approach ignores site-specific limitations and considerations. This is particularly important with regard to the implementation of potential improvement technologies. Experience indicates that specific technologies may provide substantial benefits at one plant, while the same technology may in fact impose net costs at another plant.

- A generic approach may be overly generalistic in nature. The intricacies of specific processes, technologies, and equipment are largely ignored in this approach.

As a result, this guide should be used as a starting point for site-specific evaluations in combination with other sources of knowledge and experience related to the dairy processing sector.

4.0 RESOURCE UTILIZATION

Resource use by dairy processing plants is summarized in the following sections.

4.1 Energy

Energy usage and associated costs at dairy processing plants are generally well monitored, and well understood by individual plants. Three forms of energy are primarily employed in Ontario dairy processing plants:

- Electricity, primarily for refrigeration systems and various drives;
- Natural gas, primarily for product, water and space heating requirements; and
- Liquid fuel, primarily diesel, used for product distribution fleets. Because this manual focusses on in-plant generic processes (i.e. see Chapter 3.0), separate analyses of product distribution systems are not discussed further.

Total energy cost statistics for Ontario dairy processing plants from 1992 are presented in Table 4-1. Unit energy data for Ontario plants is presented in Table 4-2.

TABLE 4-1
ENERGY COSTS FOR DAIRY PROCESSING PLANTS IN ONTARIO[15]

PARAMETER	FLUID MILK (SIC 1041)	INDUSTRIAL MILK (SIC 1049)
Number of Plants	33	56
Mean Energy Cost per Plant (including Diesel Fuel)	$462,000 per year	$323,000 per year
Mean Energy Cost per Plant (excluding Diesel Fuel)	$350,000 per year	$303,000 per year

TABLE 4-2
UNIT ENERGY COSTS FOR DAIRY PROCESSING PLANTS IN ONTARIO[16]

UNIT PARAMETER	FLUID MILK (SIC 1041)	INDUSTRIAL MILK (SIC 1049)
Raw Milk Received	1.00 billion Litres	1.33 billion Litres
Unit Energy Cost:		
• Including Diesel	1.52¢ per L Raw Milk	1.36¢ per L Raw Milk
• Excluding Diesel	1.15¢ per L Raw Milk	1.28¢ per L Raw Milk
Electrical Intensity	0.16 kWh per L Raw Milk	0.14 kWh per L Raw Milk
Natural Gas Intensity	0.85 MJ per L Raw Milk	1.67 MJ per L Raw Milk
Proportion Energy Cost:		
• Electricity	50%	57%
• Natural Gas	16%	34%
• Liquid Fuel	34%	9%

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[15] Energy cost data from Special Edition of Statistics Canada's Annual Survey of Manufacturers. 1992. Breakdowns of costs by plant size and by process subcategory are not available.

[16] Energy cost data from Special Edition of Statistics Canada's Annual Survey of Manufacturers. 1992. Plant milk usage data from Statistics Canada - Matrix 5850. Note that conversion of raw milk equivalents to milk solids is provided in Section 9.5.

Some differences exist between energy use and costs for fluid and industrial milk processing plants. The most significant is the higher natural gas costs for industrial plants per unit of raw milk. This can be explained primarily by the more energy intensive activities, such as evaporation and drying, employed for industrial milk products. Additional energy use and energy cost data for Canada is provided in Appendix B. While energy use and cost data, in general, are well documented, the collection of unit energy-use statistics is desirable for benchmarking energy use in relation to the quantity of materials processed and product produced.

4.2 Water Use

Water use within dairy processing plants in Ontario is not well documented. The lack of accurate data is due in part to the typically low cost associated with this resource in the past, and its frequent treatment as a fixed or overhead cost, rather than a variable manufacturing cost. The collection of unit water use statistics is also desirable for benchmarking purposes.

Based on data derived from U.S. Environmental Protection Agency (U.S. EPA) sponsored studies and other sources, typical dairy plant water utilization is generally considered to be within the following ranges:

- 1 to 3 Litres of water per Litre of milk for fluid milk processing plants; and

- 2 to 5 Litres of water per Litre of milk for industrial milk processing plants.

A number of Ontario dairy plants were contacted regarding water use. It was confirmed, either quantitatively or qualitatively, that water usage in Ontario plants is generally within the above mentioned ranges.

The cost of water varies from municipality to municipality. Water related charges by municipalities are typically broken into three components, as follows:

- Fresh water supply charge;
- Regular sewerage charge, when effluent water is discharged to a municipal sanitary sewer system; and
- Additional effluent surcharge based on effluent loading (i.e. effluent water flow × excess concentration of effluent parameter(s) above by-law limit), when discharged to a municipal sanitary sewer system.

The last component, the effluent surcharge, is intended to cover specified effluent parameters, and is discussed in more detail in the next section. However, an effluent surcharge is typically based on the discharge effluent flow volume. Metered water in-flow is often used to determine volumes for both feed water and effluent discharge.

Charges for water, including both fresh water and regular sewerage charges, in major Ontario municipalities range from approximately 40¢ to 90¢ per m^3. (Surcharge costs are considered separately.) Using the ranges for water use and water cost, a range of unit water costs per Litre of milk can be calculated, as presented in Table 4-3:

TABLE 4-3
CALCULATED RANGE OF UNIT WATER COSTS

PARAMETER	FLUID MILK (1041)	INDUSTRIAL (1049)
Unit Water Use Range	1 to 3 Litres per Litre	2 to 5 Litres per Litre
Water Charge Range	40¢ to 90¢ per m^3	40¢ to 90¢ per m^3
Range Unit Water Charge	0.04¢ to 0.3¢ per Litre	0.08¢ to 0.5¢ per Litre

It can be seen from these calculated values that unit water costs are still much lower than unit energy costs per Litre of raw milk, presented earlier in Table 4-2. Unit water costs are only 4% to 26% of energy costs for fluid milk plants, and 6% to 40% of energy costs for industrial milk plants.

An important consideration for plants paying fees for their discharge to municipal systems is to ensure that water incorporated into product (e.g., in juices, drinks or frozen novelties), or otherwise not discharged to sewer (e.g., evaporation losses from evaporative condensers) are not included as part of the calculation of regular sewage charges or surcharges.

4.3 Materials

The major material input requirements for dairy processing plants include the following:

- Raw milk.
- Other product ingredients.
- Packaging, storage and distribution materials.
- Cleaning and sanitation chemicals.

Excluding raw milk, the other input materials are described in more detail in the following sections.

4.3.1 Product Ingredients Other Than Milk

Ingredients, other than raw milk, are employed in dairy processing plants depending on the product involved. A summary of other ingredients, broken down by major product/process category, is provided in Table 4-4. Potential major implications to dairy processing effluents arising from these ingredients are also summarized.

TABLE 4-4
MAJOR INGREDIENTS OTHER THAN MILK IN DAIRY PROCESSING

MAJOR PROCESS/PRODUCT	MAJOR INGREDIENT CATEGORIES	IMPLICATIONS TO PROCESS EFFLUENTS
Fluid Milk	Vitamins	Negligible
	Drink/Juice Flavourings	Direct Contribution to Effluent Loading
Cheese	Coagulating Enzymes Microbial Cultures Colour	Little Direct Effects
	Salt	Effluent Salinity
Ice Cream/Frozen Products	Sugar, Whey Powder or Skim Powder	Direct Contribution to Effluent Loading
	Fruits/Nuts Flavourings	Contribute to Effluent Loading and Solids
	Stabilizers/Emulsifiers	Little Direct Effects
Cultured Products	Lactic Culture	Little Direct Effects
Butter	Salt	Effluent Salinity
Evaporated/Dried Products	Sugar (Condensed Product)	Direct Contribution to Effluent Loading

4.3.2 Packaging, Storage and Distribution Materials

A requirement for all dairy products is final packaging. Packaging is especially important given that dairy products are foods intended for human consumption. The important functions of packaging materials for dairy products include:

- Containment and protection of the product;
- Assurance of product safety and product quality in prevention of contamination;
- Convenience of product handling by consumers;
- Consumer choice;
- Dispensing of product;
- Ease of transportation; and
- Provision of a medium for imparting consumer information regarding the use and properties of the product.

A range of packaging formats is employed, as summarized in Table 4-5. The most common packaging materials are plastics, primarily polyethylene (PE) and polypropylene (PP), and paper. Polyethylene and polypropylene polymers are used because of their:

- Lower cost relative to other polymer resins;
- Functional packaging properties; and
- Lower environmental impacts.

Only virgin polymer resins are currently used for packaging that is in direct contact with food products. There is an indirect restriction by extension of B23.001 of the Federal Food and Drug regulations, which stipulates that food packaging must contain no harmful substances. With virgin materials, the content is well established and documented. However, with recycled materials, it is more difficult to ensure that the plastic would be entirely free of contaminants.

TABLE 4-5
MAJOR FINAL PACKAGING FORMATS EMPLOYED FOR DAIRY PRODUCTS

PROCESS/PRODUCT	PACKAGE FORMAT	TYPICAL MATERIAL
Fluid Milk (including Cream)	Bags	Polyethylene (PE) film
	Gable Tops	Coated paper
	Jugs	Extruded polyethylene
	Aseptic Brick	Foil/paper/PE laminate
	Creamers	PE or Polystyrene
	Bulk Bag	Polyethylene (PE) film
Cheese	Bag/Wrap	Polyethylene (PE) film
	Process Cheese Jars	Glass Jars
	Process Cheese Tubs	PE film
	Cream Cheese Bricks	Paper/foil or PE film
Ice Cream/Frozen Products	Bricks	Paper
	Retail Tubs	Polyethylene (PE) Polypropylene (PP)
	Novelty Wraps	Paper or polyethylene often with wooden sticks
	Bulk Tubs	Cardboard
Cultured Products	Individual Containers	PE/PP with foil top
	Retail Containers	PE/PP
Butter	Print Brick Wrap	Paper/foil
	Retail Tubs	PE/PP
Evaporated/Dried Products	Evap Milk Cans	Steel
	Bulk Bags (Dry Product)	Kraft paper

Retail packaging materials for dairy products have a potential to ultimately become solid wastes. This is described in more detail in a later section on solid residuals. The dairy processing industry is supportive of the National Packaging Protocol (NAPP), which calls for the quantity of packaging sent for disposal in the year 2000 to be no more than 50% of the amount sent for disposal in 1988.

A relatively low unit packaging mass has already been achieved for dairy products. The average packaging mass per unit product mass can be estimated for fluid milk, as presented in Table 4-6 using 1993 data, given the relatively small number of packaging formats and the uniformity of package sizes. As illustrated, data for 1993 shows an overall unit packaging mass of less than 15 g of packaging per kilogram of fluid milk product (<1.5% mass of product). Package sizes and formats are not as uniform for industrial products as fluid milk products. Thus, it is not possible to generate a similar estimate of packaging mass per unit mass of industrial products.

TABLE 4-6
ESTIMATE OF UNIT FLUID MILK PACKAGING MASS FOR 1993[17]

FORMAT	NUMBER IN 1993	PACKAGE MASS (g)	PACKAGE (tonnes)	PRODUCT (tonnes)	UNIT MASS (g per kg)
Bulk Fluid Milk	1.4 million	100	140	28,600	5
4 Litre Pouch	190 million	35	6,620	759,000	9
2 Litre Carton	36 million	65	2,310	71,600	32
1 Litre Carton	98 million	35	3,420	98,200	35
500 mL Carton	57 million	20	1,110	28,300	39
250 mL Carton	110 million	15	1,700	28,300	60
Milkette	200 million	1	200	2,600	77
TOTAL			15,500	1,026,000	15

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[17] Data from Bulletin No. 674A - Annual Supplement, 1993

In addition to final packaging, a variety of intermediate storage and distribution materials are also employed in dairy processing plants. These include:

- Cases for product package shipment.
- Intermediate storage boxes for cheese.
- Pallets for products and feed materials.
- Totes and barrels for ingredients and cleaning chemicals.

4.3.3 Cleaning and Sanitation Chemicals

Dairy processing operations use significant quantities of cleaning and sanitizing agents. All process systems are regularly cleaned and disinfected to minimize the potential for microbial contamination. The processing systems typically incorporate automated cyclic Clean-in-Place (CIP) operations, although equipment may also be manually Cleaned-Out-of-Place (COP). Four major types of cleaning and sanitizing products are employed:

- Alkaline solutions, typically incorporating concentrated caustic soda (sodium hydroxide) as detergent agents for cleaning.

- Blended alkaline detergents, incorporating alkali, typically sodium hydroxide, polyphosphates, surfactants and chelating agents.

- Acid solutions, typically incorporating nitric and/or phosphoric acid, especially for removal of encrusted proteins.

- Disinfectant/sanitizer agents that may be acidic, basic or neutral. Typical agents include quaternary ammonium compounds, halogen derivatives, sodium hypochlorite and chloramine.

The cleaning and sanitizing agents used in dairy processing plants have implications with regard to effluents, as discussed in the next section.

5.0 PROCESS RESIDUALS

Important process residuals of dairy processing operations are summarized in the following sections.

5.1 Air Residuals

There are four major potential air residuals important for dairy processing operations. These are discussed in order of priority as follows:

- Particulate Emissions from Drying Operations. Particulate emissions result from milk product and whey drying operations, of which there are 10 plants in the province. Such emissions are significant from a compliance perspective, as they fall under the requirements of Regulation 346 of the Ontario *Environmental Protection Act*. Typically, baghouses or wet scrubbers are employed to ensure that particulate emissions are maintained at satisfactory levels.

- Combustion Emissions. Boilers and heaters used to produce process heat contribute emissions from the combustion of fuels, in most cases natural gas. Such emissions will include CO_2, as well as NO_x, and small quantities of SO_2, CO and other constituents depending on the fuel and combustion conditions. Combustion emissions can be directly reduced by improvements in plant energy efficiency. A series of emission factors applicable to combustion operations are included in Table 5-1.

- Cooling Towers Emissions. Cooling towers are frequently employed for recirculated cooling systems, such as part of refrigeration cycles.

- Odour Emissions. Odours, whether emanating from process operations or waste treatment facilities can be problematic, however, tend to be very site specific.

TABLE 5-1: NATURAL GAS COMBUSTION SYSTEM EMISSIONS FACTORS

CONSTITUENT	CONDITIONS	KG OF EMISSIONS PER MILLION CUBIC METERS OF NATURAL GAS		
		Large Boilers (> 100 million BTU/h)	Small Boilers (10-100 million BTU/h)	Commercial Boilers (0.3-10 million BTU/h)
Carbon Dioxide		ND	1.9 E + 06	1.9 E + 06
Total Organic Carbon		28	92	128
Sulfur Dioxide		9.6	9.6	9.6
Nitrogen Oxides				
	Uncontrolled	8800	2240	1600
	Low NO_x Burner	1300	1300	270
	Flue Gas Recirc	850	480	580

Note ND = No Data Available.

Emission Factors as cited in U.S. EPA AP-42 summary of emission factor data

5.2 Liquid Residuals (Wastewater)

Dairy processing plants are significant generators of liquid effluents and effluent loadings. The nature of effluents and loadings for dairy processing plants are summarized in the following sections.

5.2.1 Effluent Discharge Alternatives

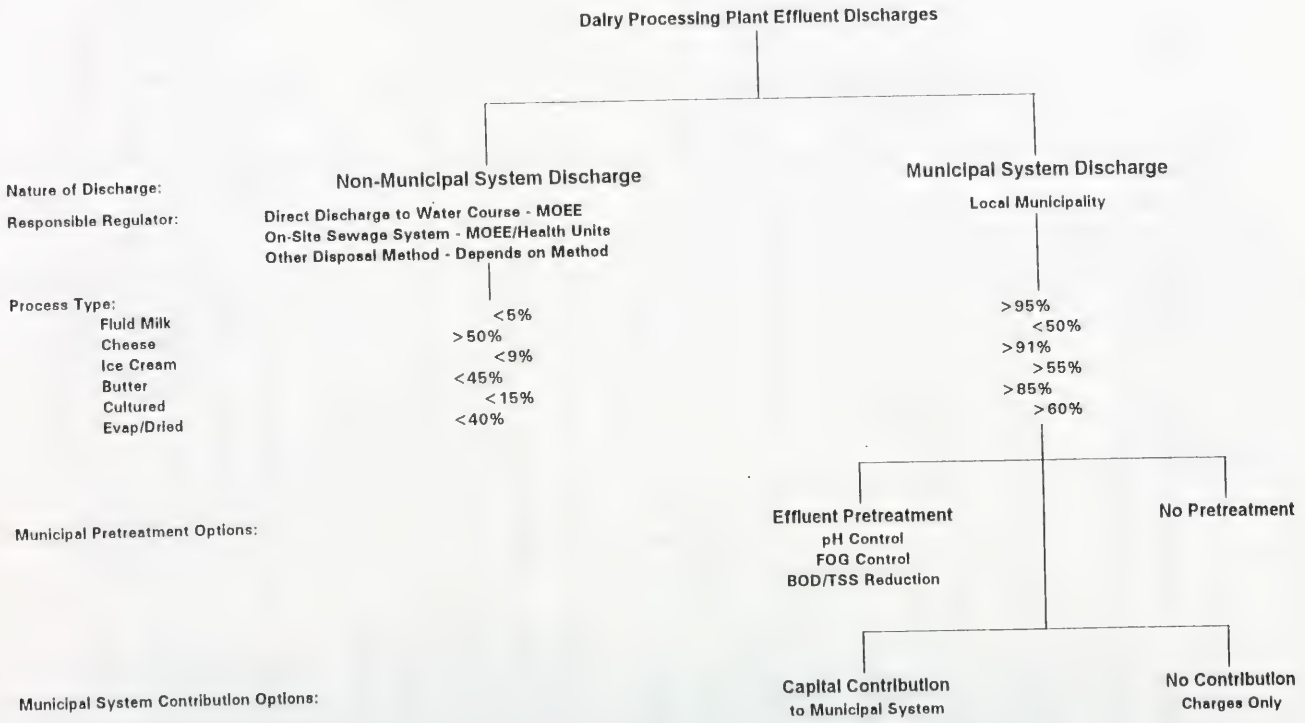
A number of effluent discharge alternatives are employed by dairy processing plants in Ontario, as summarized in Figure 5.1. The first major distinction in effluent management is whether or not a plant discharges to a municipal sewer system.

The approximate proportions of dairy processing plants within each of the six major process/product categories employing these two alternatives are summarized in Figure 5.1. A detailed summary of plant discharges is provided in Appendix C. As indicated in Figure 5.1, the plants can essentially be divided into two groups:

- Fluid milk, ice cream and cultured product plants, of which a high proportion discharge to municipal systems. The coincidence of these processes makes sense, given the relatively high level of association between the three process activities. For example, fluid milk plants almost exclusively discharge to municipal systems, and a high proportion of fluid plants, more than 25%, are also involved in ice cream/frozen products or cultured products manufacture.

- Cheese, butter and evaporated/dried product plants, of which a significant proportion are non-municipal system dischargers. The highest proportion of such dischargers are cheese plants, which tend to be located more in rural areas, as opposed to fluid milk plants, which tend to be located in urban areas. Butter and evaporated/dried product processes occur primarily at the same plants.

FIGURE 5.1: Ontario Dairy Processing Plant Effluent Discharge Alternatives



As also illustrated in Figure 5.1, plants discharging to a municipal system may:

- Incorporate effluent pretreatment; and/or
- Provide a capital contribution to municipal treatment systems.

These decisions, however, tend to be site/plant specific, with no aggregate data available. Common pretreatment processes include:

- pH adjustment.
- Dissolved air flotation (DAF) for coagulation and removal of fat and protein constituents, but not solubles.
- BOD reduction, including such processes as trickling filter.

5.2.2 Effluent Loading Parameters and Sources

The major effluent parameters of concern to dairy processing plants include the following:

- Biological oxygen demand (5 day) or BOD_5, which measures the oxygen required to biologically consume organics in an effluent flow;
- Total suspended solids (TSS);
- Solvent extractable matter of animal or vegetable origin, often termed Fats, Oil and Grease (FOG);
- Phosphorus, usually measured and expressed as total phosphorus (TP);

- Nitrogen, including constituents such as ammonium-nitrogen and total Kjeldahl nitrogen (TKN); and

- pH, which measures levels of acidity or alkalinity of the effluent flow.

Potential contributing sources of these parameters are primarily product losses (milk and other product constituents) and cleaning chemicals, as summarized in Table 5-2.

TABLE 5-2
SOURCES OF DAIRY PRODUCT PLANT EFFLUENT PARAMETERS

PARAMETER	POTENTIAL SOURCES
BOD	Milk and other Products from Losses and Rinses - butter fat, protein, lactose and other sugars.
	Conveyor Lubricants - small source.
TSS	Milk from Losses and Rinses - butterfat as a globular emulsion.
FOG	Milk from Losses and Rinses - butterfat.
Phosphorus	Cleaning Chemicals - contain phosphate and phosphoric acid.
	Milk from Losses and Rinses - contains phosphorus.
Nitrogen	Cleaning Chemicals - contain nitric acid and other nitrogen compounds.
	Milk from Losses and Rinses - contains nitrogen.
pH	Cleaning Chemicals - both acid and caustic cleaner employed.

5.2.3 Range of Effluent Parameter Values

Effluent characteristics for individual plants can vary significantly. Ranges and average values of the important effluent parameters, derived from U.S. EPA sponsored work, are presented in Table 5-3. Although derived from research work in the early 1980's, these values are still frequently cited and still considered to be relevant.

TABLE 5-3
TYPICAL EFFLUENT PARAMETER RANGES AND AVERAGE VALUES FOR DAIRY PROCESSING PLANTS (BASED ON U.S. EPA DATA)[18]

PARAMETER	EXPECTED RANGE	EXPECTED AVERAGE
BOD	500 to 5,000 mg/L	2,300 mg/L
TSS	400 to 3,500 mg/L	820 mg/L
FOG	200 to 3,000 mg/L	450 mg/L
Nitrogen		56 mg/L
Phosphorus		33 mg/L
Total Effluent Volume	0.5 to 70 L per L of product	

5.2.4 Biological Oxygen Demand

Dairy processing plants are significant generators of effluent BOD. Although other effluent parameters are generated by dairy processing plants, BOD is typically the highest concentration effluent parameter at dairy processing plants. The approximate BOD contributions of various milk components and other relevant compounds are summarized in Table 5-4.[19]

TABLE 5-4
BOD CONTRIBUTIONS OF MILK CONSTITUENTS

COMPONENT	BOD CONTRIBUTION (kg BOD per kg Component)
Milk Lactose Sugar	0.7
Milk Fat	0.9
Milk Protein	1.0
Glucose (added to Drinks and Ice Cream Mix)	0.7
Soap Surfactant (high BOD but low quantity)	1.4

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[18] As cited in Carawan, Parkin and Harper. 1984. Waste Management Control Handbook for Dairy Food Plants. U.S. EPA Industrial Environmental Research Laboratory. EPA-600/2-84-043. p2 and p73. and other sources.

[19] Ibid. p49.

Based on reported BOD values for milk solids constituents, as well as direct BOD analyses of milk[20], the following generalizations can be made regarding the contribution of milk and milk solids to BOD:

$$1\ kg\ BOD \approx 1\ kg\ Milk\ Solids \approx 10\ Litres\ Milk\ (Equivalent)$$

Frequently cited BOD generation factors for milk plants, based on EPA data, are listed as follows:

- Approximately 3 kg BOD per 1,000 kg of milk for Fluid milk production.
- Up to approximately 12 kg BOD per 1,000 kg for Ice Cream production.
- Higher values for cheese production, depending on disposal of whey.

Direct discharging plants, which provide on-site treatment in Private Sewage Treatment (PST) facilities, must ensure final BOD does not exceed specific limits as prescribed by the MOEE.

Plants discharging to municipal sewer systems with effluent BOD concentrations that exceed By-Law limits may enter into a surcharge agreement, under which an additional surcharge is paid for the excess BOD. Municipal surcharge formulas and associated charges vary significantly among municipalities, and no compiled data is available for the province. Within major industrialized municipalities, the effective surcharge for excess BOD typically ranges from approximately 30¢ to 55¢ per kg of BOD. The equivalent charge per kg of BOD can be even higher in smaller municipal centres.

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[20] For example, a BOD result of 108,000 mg/L was obtained for 2% milk (with approximately 11% total milk solids) in test conducted for Wardrop Engineering Inc. in June, 1994 at Environmental Protection Laboratories Inc. (Ref # 941929).

While reduction of BOD can lead to surcharge reductions, it is important to note that such savings are small compared to the potential savings in recovered product. Using a cost range of 30¢ to 55¢ per kg of BOD, together with the BOD-to-milk equivalent conversion presented earlier, the BOD value of lost milk can be calculated as approximately 3¢ to 6¢ per Litre. This is much lower than the typical cost of raw milk to dairy processing plants, in the range of approximately 50¢ to 60¢ per Litre.

5.2.5 Whey Management

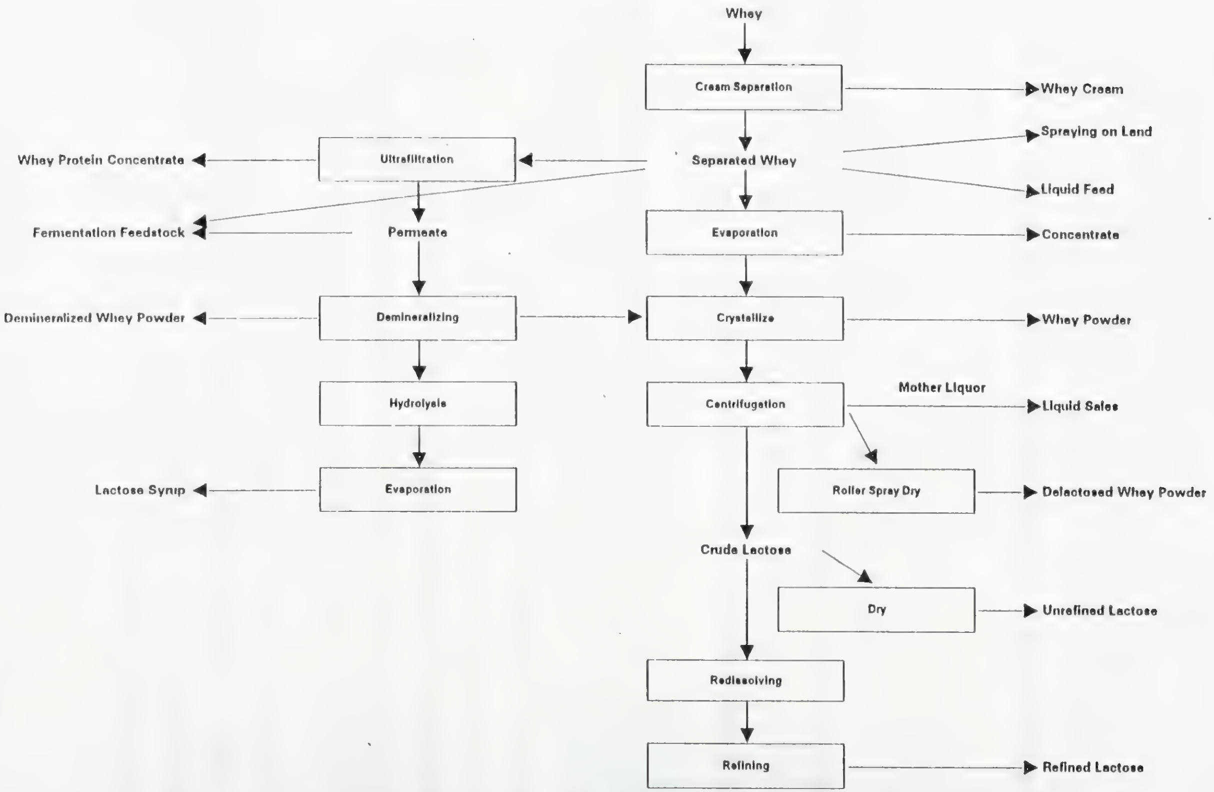
An especially strong potential source of BOD from dairy processing operations is whey from cheese production. Whey is the residual liquid expressed after cheese has been coagulated. It contains lactose sugar, as well as some protein and fat. It has a high BOD, approximately 25% to 30% that of whole milk.

The management of whey, whether it is used or simply discarded, thus has an important impact on potential effluent BOD. Large firms producing cheese in Ontario already have their own facilities to utilize whey. The range of process options available is presented in Figure 5.2. Major applications in Ontario now include:

- Concentration and drying of whey to produce whey powder.
- Production of whey protein concentrates and other protein derivatives.
- Production of lactose or modified lactose products, such as lactulose.

Whey management is potentially problematic for small cheese production plants. As discussed earlier, a significant proportion of industrial milk processing plants in Ontario are small cheese plants. There is no ideal solution to deal with whey. All impose costs and process design considerations.

FIGURE 5.2: Options for Further Processing of Whey



Taken From: Zadow, J.G. 1986. Utilization of Milk Components: Whey. Modern Dairy Technology. Volume 1: Advances in Milk Processing. Elsevier Applied Science Publishers.

Five major whey management alternatives are available to smaller plants, as follows:

- Application to agricultural lands.[21] Suitable sites are required to be authorized and application rates are strictly controlled. Costs can be incurred for storage hauling and land spreading.

- Discharge to municipal sanitary system or PST for treatment. The high BOD load associated with whey imposes treatment costs.

- Shipment to large plants for further processing. Currently a number of small operations are shipping whey to larger plants. This can impose haulage costs. Also, a large plant must be in a position to desire additional whey material.

- Feeding to livestock. It may be possible to feed whey to livestock. This use is covered by feed regulations.

- Further processing of whey to other products. Conversion processes, such as drying, can be capital intensive, and impose economies of scale that can preclude such operations in smaller operations. Products can also suffer from low value (e.g., whey powder) and/or market volatility. Further processing can also create subsidiary environmental concerns, such as BOD containing permeates from membrane processing.

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[21] Refer to: MOEE and OMAFRA. 1992. Draft Interim Guidelines for the Utilization of Waste (Other than Sewage Sludge) on Agricultural Lands.

5.2.6 Phosphorus and Nitrogen

Specific nutrient parameters of concern are phosphorus and nitrogen. Phosphorus and nitrogen are present in milk, however, the largest sources of both nutrients are the chemicals used for process system cleaning and sanitizing. Nitrogen and, especially, phosphorus containing chemicals are very effective for cleaning and sanitization. Alternative cleaning chemicals are available, and coming into the market in increasing numbers. However, alternative cleaning chemicals may yet suffer from other disadvantages, including reduced effectiveness and increased aggressiveness and corrosion.

Environmental controls seek to reduce the discharge of phosphorus and nitrogen, which are both nutrients contributing to eutrophication in surface waters. However, at the same time, dairy processing plants must be appropriately cleaned and disinfected at periodic intervals, to satisfy food safety requirements. Adequate cleaning often requires the use of phosphorus and nitrogen containing chemicals.

Phosphorus and nitrogen effluent loadings are important for both direct dischargers and plants discharging to municipal systems.

In the case of direct dischargers, phosphorus limits are established by the Ministry. In the case of municipal dischargers, municipal by-law concentration limits are established for phosphorus and nitrogen. These effluent concentration and/or loading limits are usually much lower than the limit for BOD. BOD is typically the parameter in largest excess, and therefore, of principle concern. However, as plants discharging to municipal systems reduce their product losses, and correspondingly their BOD discharges, potential excess phosphorus and/or nitrogen may become much more important in the future.[22]

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[22] Note that TSS and FOG can also be excess parameters, however, these, like BOD, result primarily from product losses. Reduction of product losses will also result in TSS and FOG reduction.

5.3 Solid Waste Residuals

A number of solid waste residuals result from dairy processing operations, including packaging materials and sludges, which are discussed in the following sections.

5.3.1 Packaging Residuals

The most important solid waste residual of dairy processing results from packaging. Given the nature of consumption of milk and milk products, the majority of packages involve relatively small individual volumes. This leads to a large number of relatively small packages that are widely dispersed. Once the product is consumed, the package becomes a post-consumer solid waste.

Environmental imperatives seek to reduce packaging, while food safety requires that packaging standards be maintained. While it is incumbent upon the industry to manage its packaging through reduction, reuse and recycling, the function of packaging cannot be compromised.

A number of initiatives have been undertaken to reduce packaging wastes. These include the following:

- Suppliers of milk packaging, in concert with the processing industry, have been (1) working to reduce the amount of raw material used in their packaging, (2) supporting recycling programs, and (3) developing end-use markets for their packaging while ensuring that the needs of the consumer are met.

- Plastic packaging for all dairy products displays the SPI "Plastics Recycling Coding System" which provides a universal identification system designed to assist consumers with sorting various plastic resin types.

- Changes in butter wrappers in some cases have reduced packaging of that product by 90%.
- Large blocks (640 lb.) of processed cheese are packaged and shipped in cardboard containers that are reused.
- Natural cheese in 640 lb. blocks is being packaged and shipped in wooden crates that are being reused.
- Minimum (post-use) recycled fibre specifications are established in corrugated and paperboard packaging containers.
- Heavy metals in packaging inks and adhesives are eliminated.
- Promotional material coatings on packaging (labelling) is converted to water-soluble products.
- Source reduction - using streamlined pouches instead of bulky rigid containers.
- Implementation of a reusable pallet program.
- Implementation of a milk case deposit system.
- Plant cleaning supplies are received in large plastic returnable totes, which are refilled as needed, substituting for the use of 45 gallon drums.
- Initiation of packaging audits.

5.3.2 Sludge Residuals

A number of sludge residuals can result from dairy processing operations, primarily from waste treatment or pretreatment. These can include:

- Sludges from dissolved air flotation (DAF) units. These sludges will often contain coagulation polymers which preclude use for animal feeding applications. A variety of improved "feed-friendly" polymers are becoming more readily available.
- Sludges from biological treatment operations.

Methods of utilizing sludges include animal feeding, if acceptable, or agricultural land application.

6.0 GENERIC PROCESS AND UTILITY DESCRIPTIONS

Generic process descriptions are provided for each of the six major processes identified earlier in Section 3.0. Each of the process descriptions is presented concisely in the form of a block flow diagram, indicated as follows:

- Fluid Milk Processing - Figure 6.1.

- Cheese Processing - Figure 6.2. Cheddar cheese processing is specifically highlighted, however, other cheese processes are relatively similar. Whey processing is also included.

- Ice Cream and Other Frozen Products - Figure 6.3.

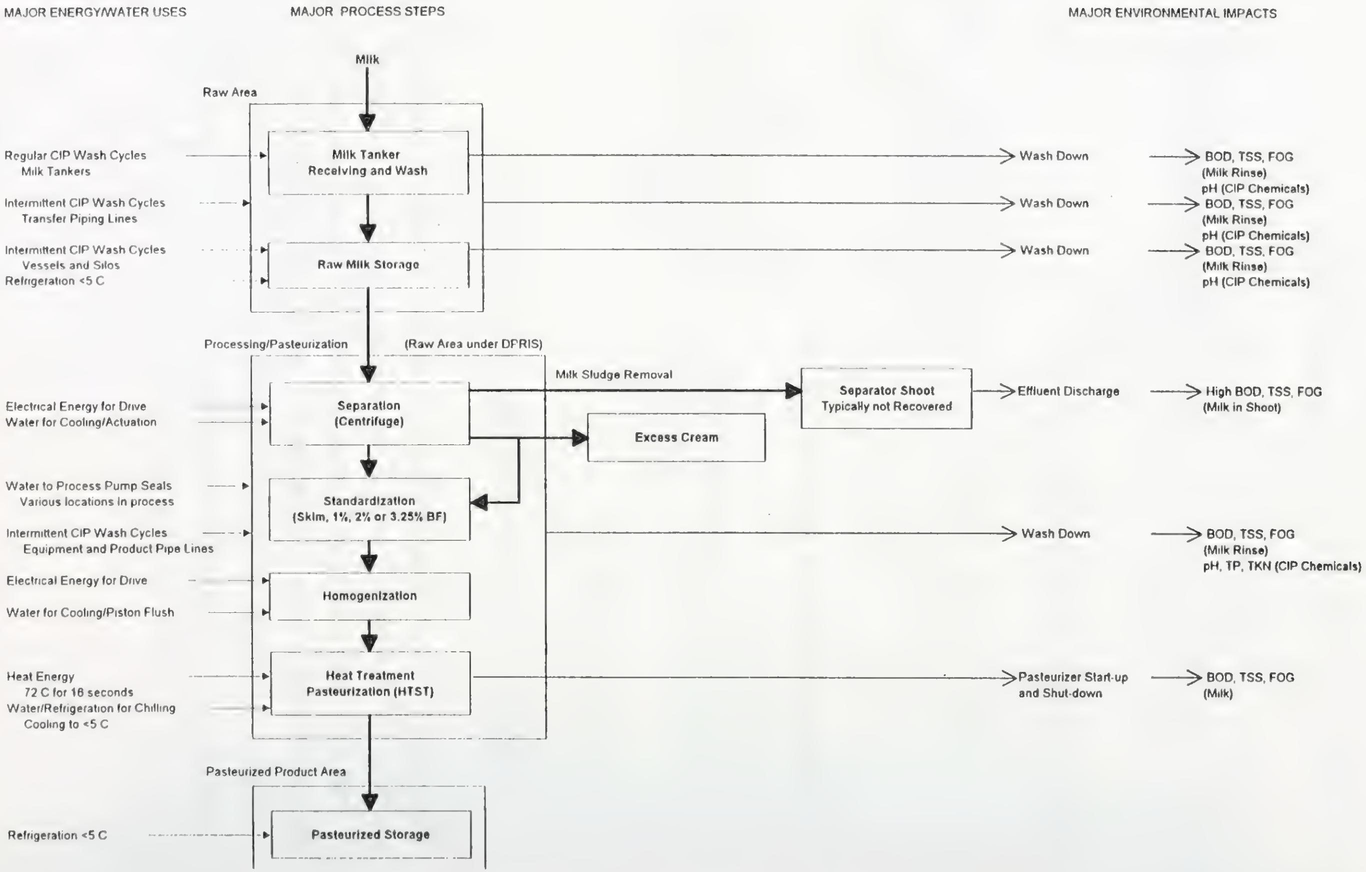
- Cultured Products - Figure 6.4. Yoghurt processing is specifically highlighted, however, other cultured product processes are relatively similar.

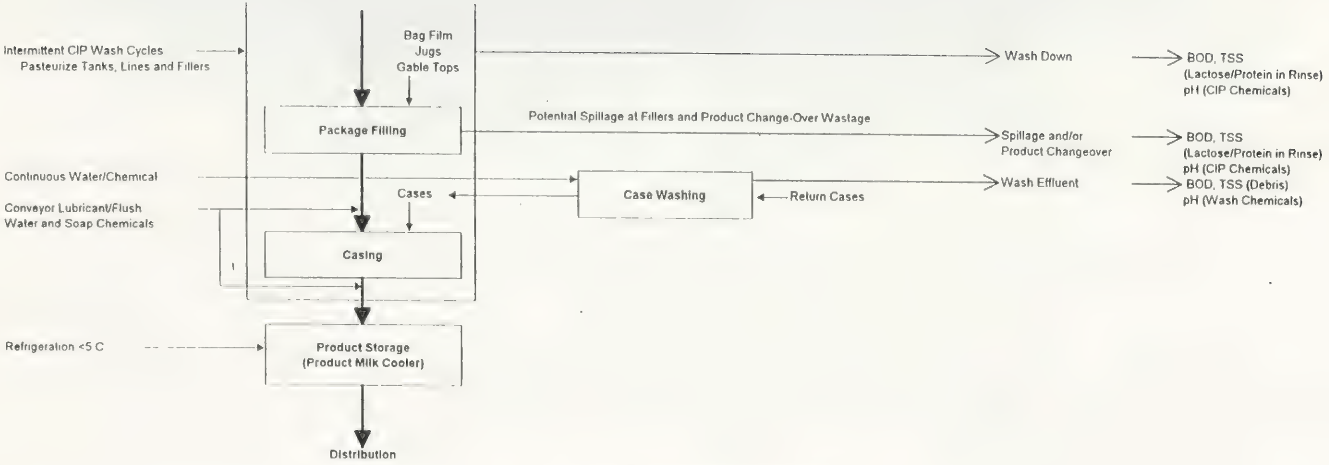
- Butter - Figure 6.5.

- Evaporated and Dried Product Processing - Figure 6.6.

These generic process descriptions include all the relevant steps, presented in a manner consistent with the models currently being developed for HACCP. On the left side of each diagram, high energy and water uses are highlighted at each relevant step, while major environmental effects are highlighted on the right. The typical utility and service demands for dairy processing plants are summarized in Table 6-1. The importance of the different utilities can vary between processes, as indicated. Utility requirements also vary to some extent between different plants producing the same product.

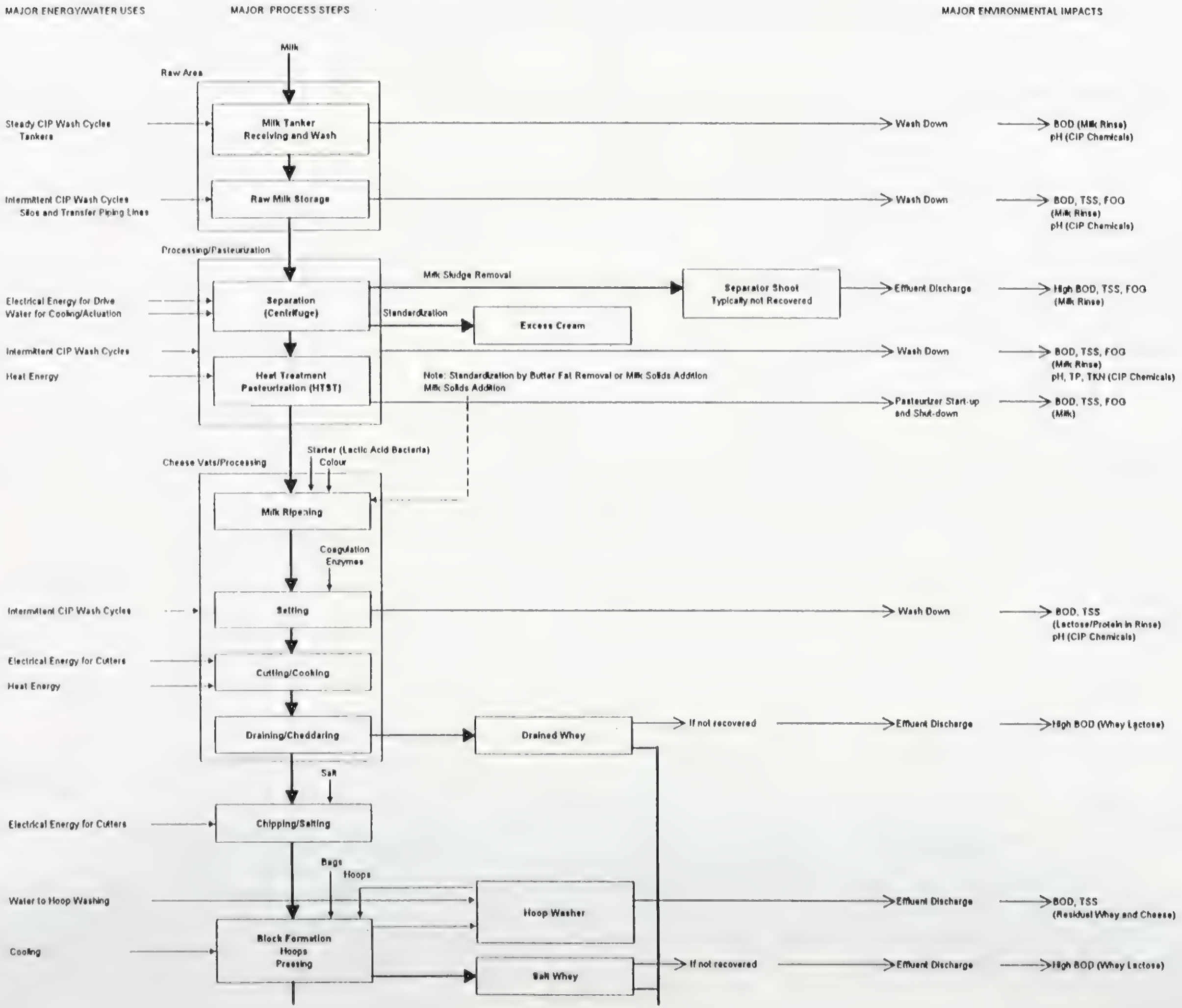
FIGURE 6.1: Process Flow Diagram for Fluid Milk Processing

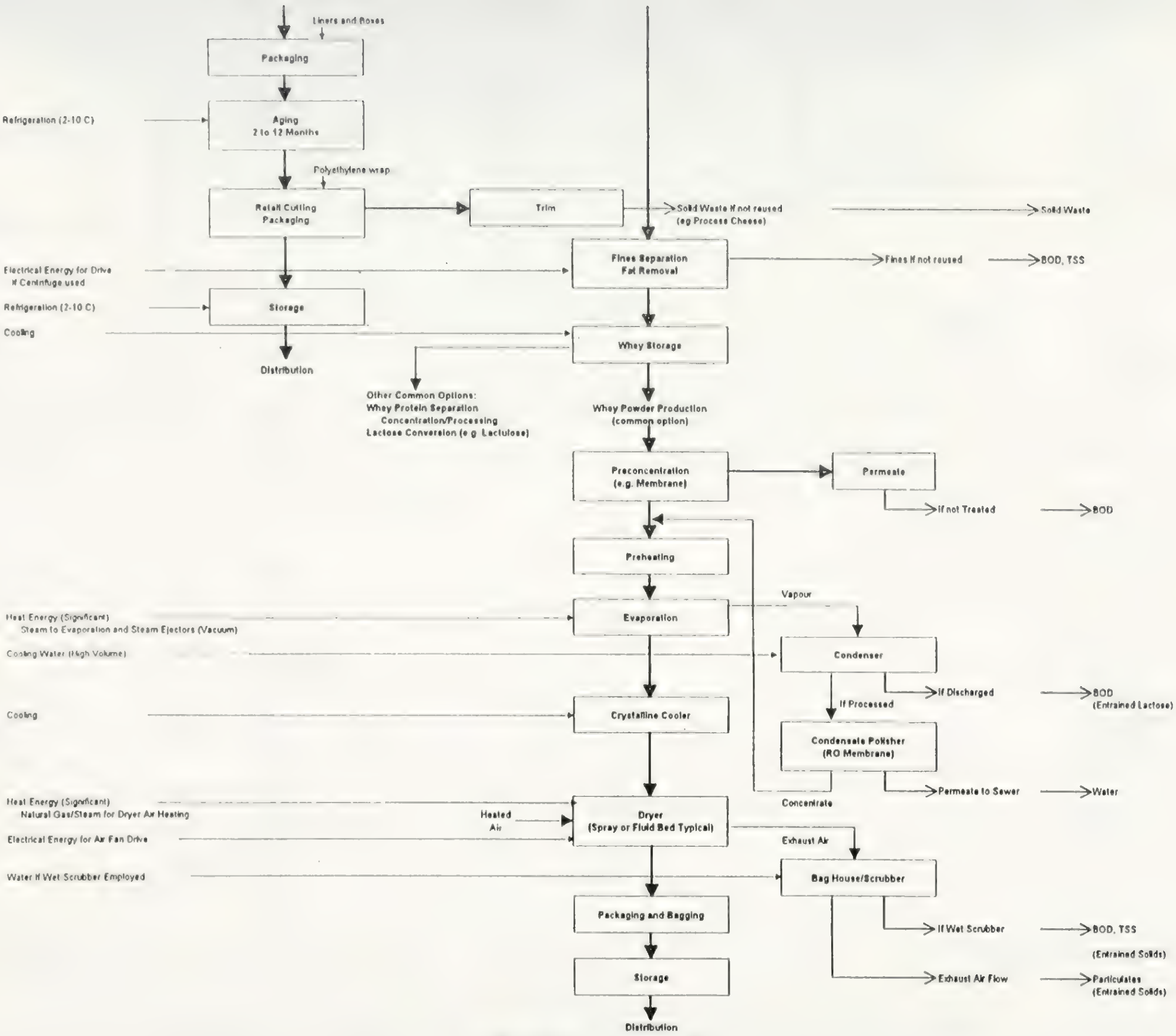




Refer to Table 7.1 for Improvement Opportunities

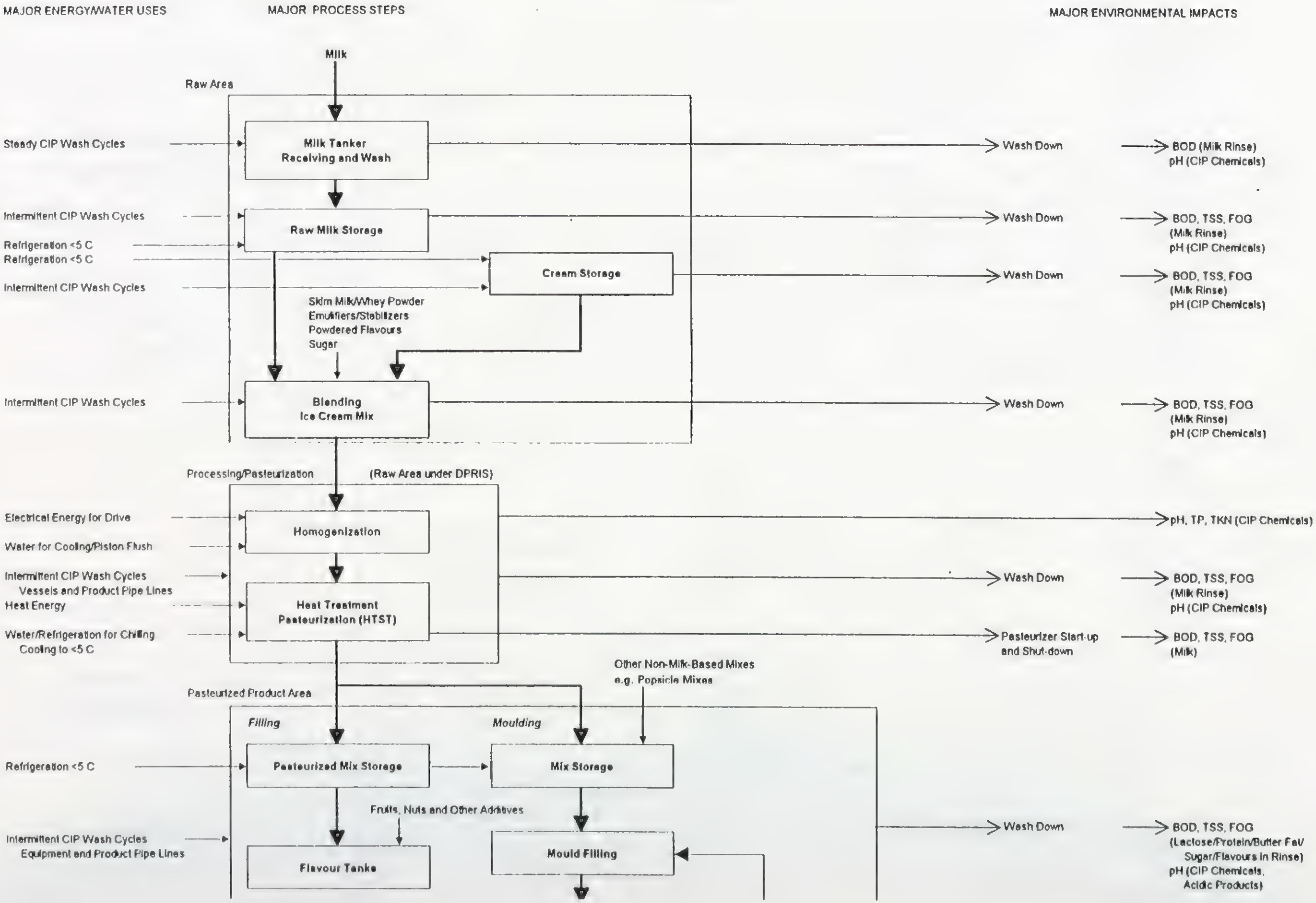
FIGURE 6.2: Process Flow Diagram for Cheddar Cheese Manufacture and Associated Whey Processing

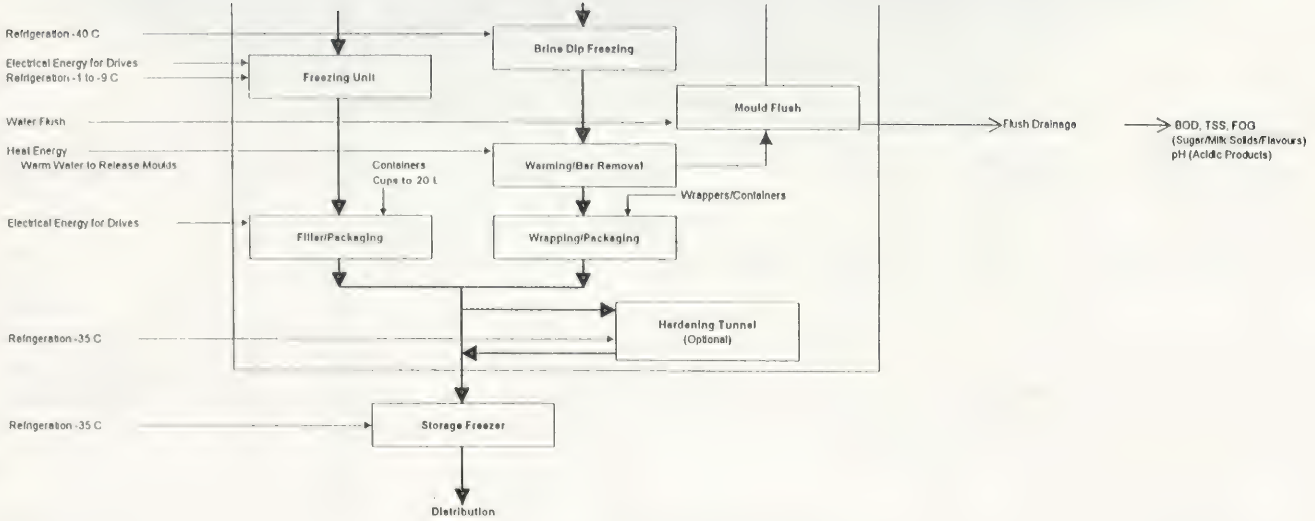

MAJOR ENERGY/WATER USES
MAJOR PROCESS STEPS
MAJOR ENVIRONMENTAL IMPACTS
Milk
Raw Area
Steady CIP Wash Cycles Tankers
Milk Tanker Receiving and Wash
Wash Down
BOD (Milk Rinse) pH (CIP Chemicals)
Intermittent CIP Wash Cycles Silos and Transfer Piping Lines
Raw Milk Storage
Wash Down
BOD, TSS, FOG (Milk Rinse) pH (CIP Chemicals)
Processing/Pasteurization
Electrical Energy for Drive
Water for Cooling/Actuation
Separation (Centrifuge)
Milk Sludge Removal
Separator Shoot Typically not Recovered
Effluent Discharge
High BOD, TSS, FOG (Milk Rinse)
Standardization
Excess Cream
Intermittent CIP Wash Cycles
Wash Down
BOD, TSS, FOG (Milk Rinse) pH, TP, TKN (CIP Chemicals)
Heat Energy
Heat Treatment Pasteurization (HTST)
Note: Standardization by Butter Fat Removal or Milk Solids Addition Milk Solids Addition
Pasteurizer Start-up and Shut-down
BOD, TSS, FOG (Milk)
Cheese Vats/Processing
Starter (Lactic Acid Bacteria)
Colour
Milk Ripening
Coagulation Enzymes
Intermittent CIP Wash Cycles
Setting
Wash Down
BOD, TSS (Lactose/Protein in Rinse) pH (CIP Chemicals)
Electrical Energy for Cutters
Heat Energy
Cutting/Cooking
Draining/Cheddaring
Drained Whey
If not recovered
Effluent Discharge
High BOD (Whey Lactose)
Salt
Electrical Energy for Cutters
Chipping/Salting
Bags
Hoops
Water to Hoop Washing
Hoop Washer
Effluent Discharge
BOD, TSS (Residual Whey and Cheese)
Cooling
Block Formation Hoops Pressing
Salt Whey
If not recovered
Effluent Discharge
High BOD (Whey Lactose)



Refer to Table 7.2 for Improvement Opportunities

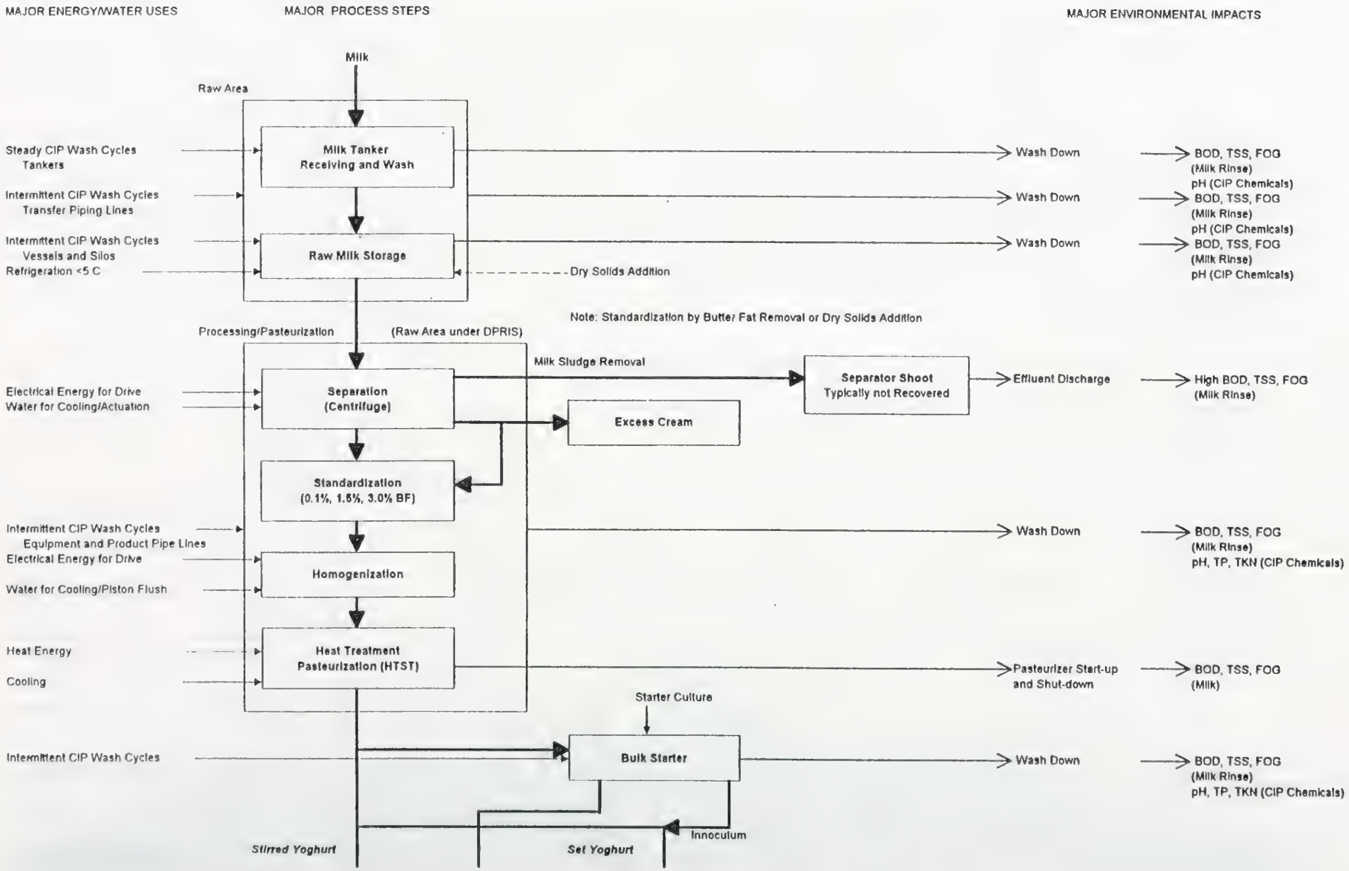
FIGURE 6.3: Process Flow Diagram for Ice Cream and Frozen Products Processing

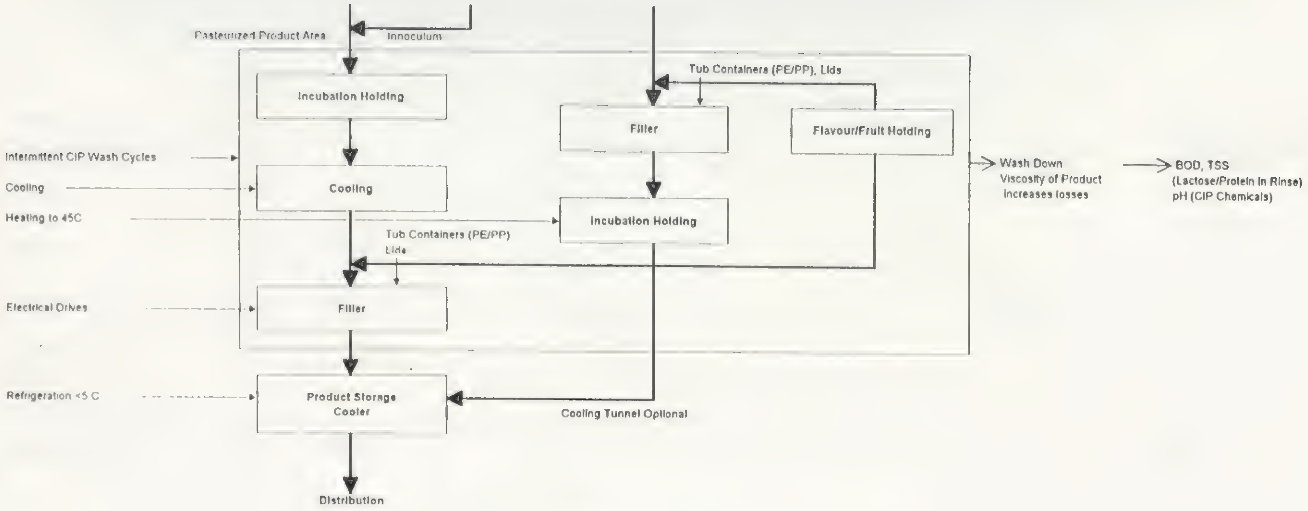

MAJOR ENERGY/WATER USES
MAJOR PROCESS STEPS
MAJOR ENVIRONMENTAL IMPACTS
Milk
Raw Area
Steady CIP Wash Cycles
Milk Tanker Receiving and Wash
Wash Down
BOD (Milk Rinse) pH (CIP Chemicals)
Intermittent CIP Wash Cycles
Raw Milk Storage
Wash Down
BOD, TSS, FOG (Milk Rinse) pH (CIP Chemicals)
Refrigeration <5 C
Refrigeration <5 C
Intermittent CIP Wash Cycles
Cream Storage
Wash Down
BOD, TSS, FOG (Milk Rinse) pH (CIP Chemicals)
Skim Milk/Whey Powder
Emulsifiers/Stabilizers
Powdered Flavours
Sugar
Intermittent CIP Wash Cycles
Blending Ice Cream Mix
Wash Down
BOD, TSS, FOG (Milk Rinse) pH (CIP Chemicals)
Processing/Pasteurization
(Raw Area under DPRIS)
Electrical Energy for Drive
Homogenization
pH, TP, TKN (CIP Chemicals)
Water for Cooling/Piston Flush
Intermittent CIP Wash Cycles Vessels and Product Pipe Lines
Wash Down
BOD, TSS, FOG (Milk Rinse) pH (CIP Chemicals)
Heat Energy
Heat Treatment Pasteurization (HTST)
Water/Refrigeration for Chilling Cooling to <5 C
Pasteurizer Start-up and Shut-down
BOD, TSS, FOG (Milk)
Other Non-Milk-Based Mixes e.g. Popsicle Mixes
Pasteurized Product Area
Filling
Moulding
Refrigeration <5 C
Pasteurized Mix Storage
Mix Storage
Fruits, Nuts and Other Additives
Intermittent CIP Wash Cycles Equipment and Product Pipe Lines
Flavour Tanks
Mould Filling
Wash Down
BOD, TSS, FOG (Lactose/Protein/Butter Fat/ Sugar/Flavours in Rinse) pH (CIP Chemicals, Acidic Products)



Refer to Table 7.3 for Improvement Opportunities

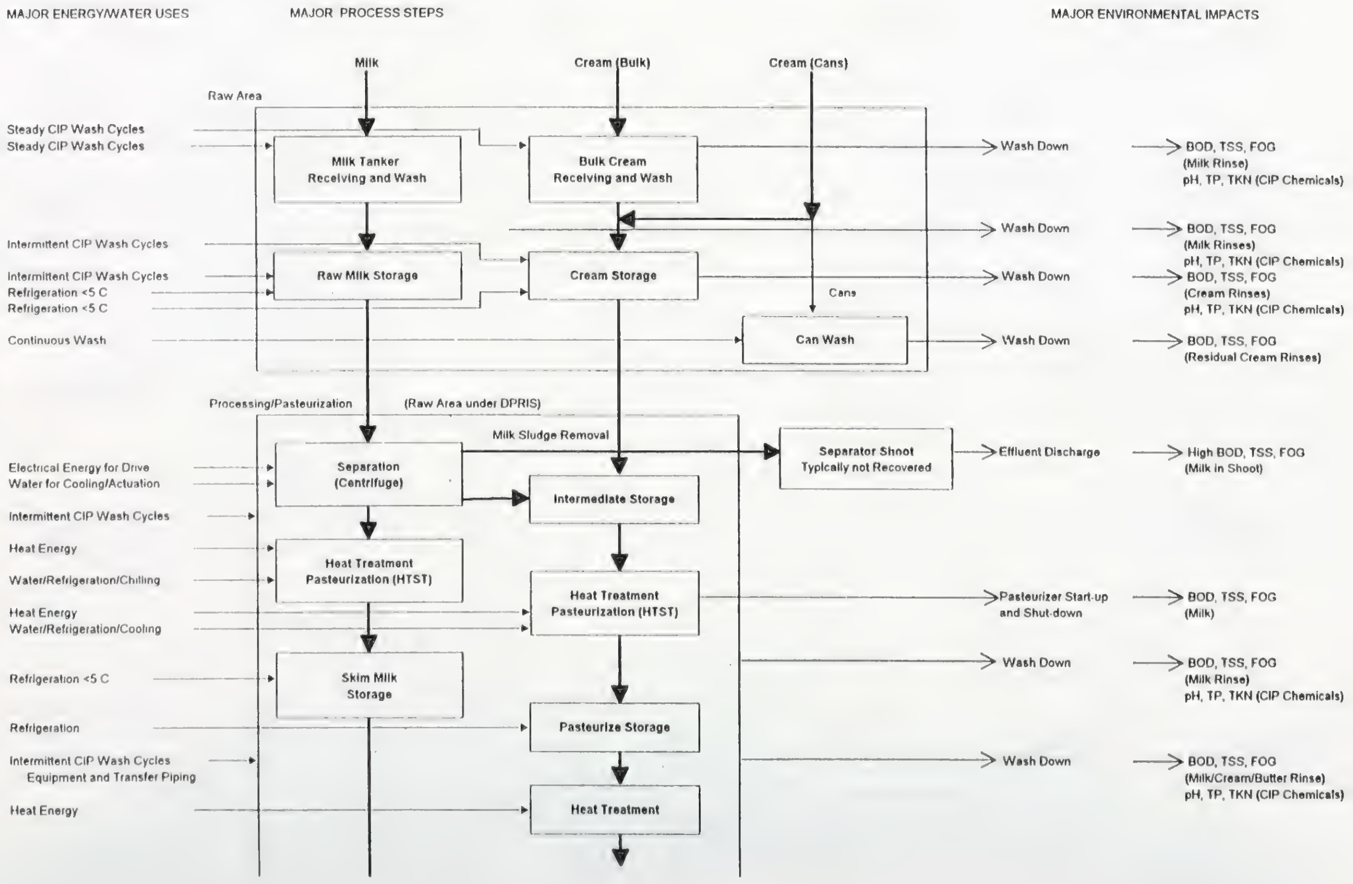
FIGURE 6.4: Process Flow Diagram for Yoghurt (Cultured Product) Processing

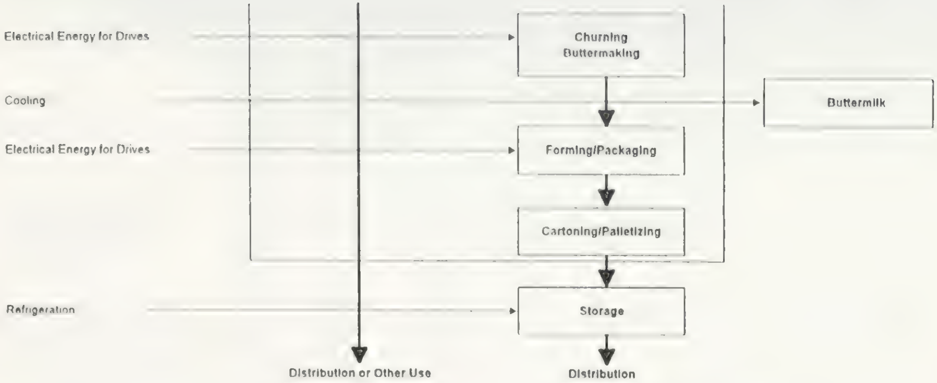

MAJOR ENERGY/WATER USES
MAJOR PROCESS STEPS
MAJOR ENVIRONMENTAL IMPACTS
Milk
Raw Area
Steady CIP Wash Cycles Tankers
Intermittent CIP Wash Cycles Transfer Piping Lines
Intermittent CIP Wash Cycles Vessels and Silos
Refrigeration <5 C
Milk Tanker Receiving and Wash
Raw Milk Storage
Dry Solids Addition
Wash Down
BOD, TSS, FOG (Milk Rinse) pH (CIP Chemicals)
Wash Down
BOD, TSS, FOG (Milk Rinse) pH (CIP Chemicals)
Wash Down
BOD, TSS, FOG (Milk Rinse) pH (CIP Chemicals)
Note: Standardization by Butter Fat Removal or Dry Solids Addition
Processing/Pasteurization
(Raw Area under DPRIS)
Milk Sludge Removal
Electrical Energy for Drive
Water for Cooling/Actuation
Separation (Centrifuge)
Separator Shoot Typically not Recovered
Effluent Discharge
High BOD, TSS, FOG (Milk Rinse)
Excess Cream
Standardization (0.1%, 1.5%, 3.0% BF)
Intermittent CIP Wash Cycles Equipment and Product Pipe Lines
Electrical Energy for Drive
Water for Cooling/Piston Flush
Homogenization
Wash Down
BOD, TSS, FOG (Milk Rinse) pH, TP, TKN (CIP Chemicals)
Heat Energy
Cooling
Heat Treatment Pasteurization (HTST)
Pasteurizer Start-up and Shut-down
BOD, TSS, FOG (Milk)
Starter Culture
Intermittent CIP Wash Cycles
Bulk Starter
Wash Down
BOD, TSS, FOG (Milk Rinse) pH, TP, TKN (CIP Chemicals)
Innoculum
Stirred Yoghurt
Set Yoghurt



Refer to Table 7.4 for Improvement Opportunities

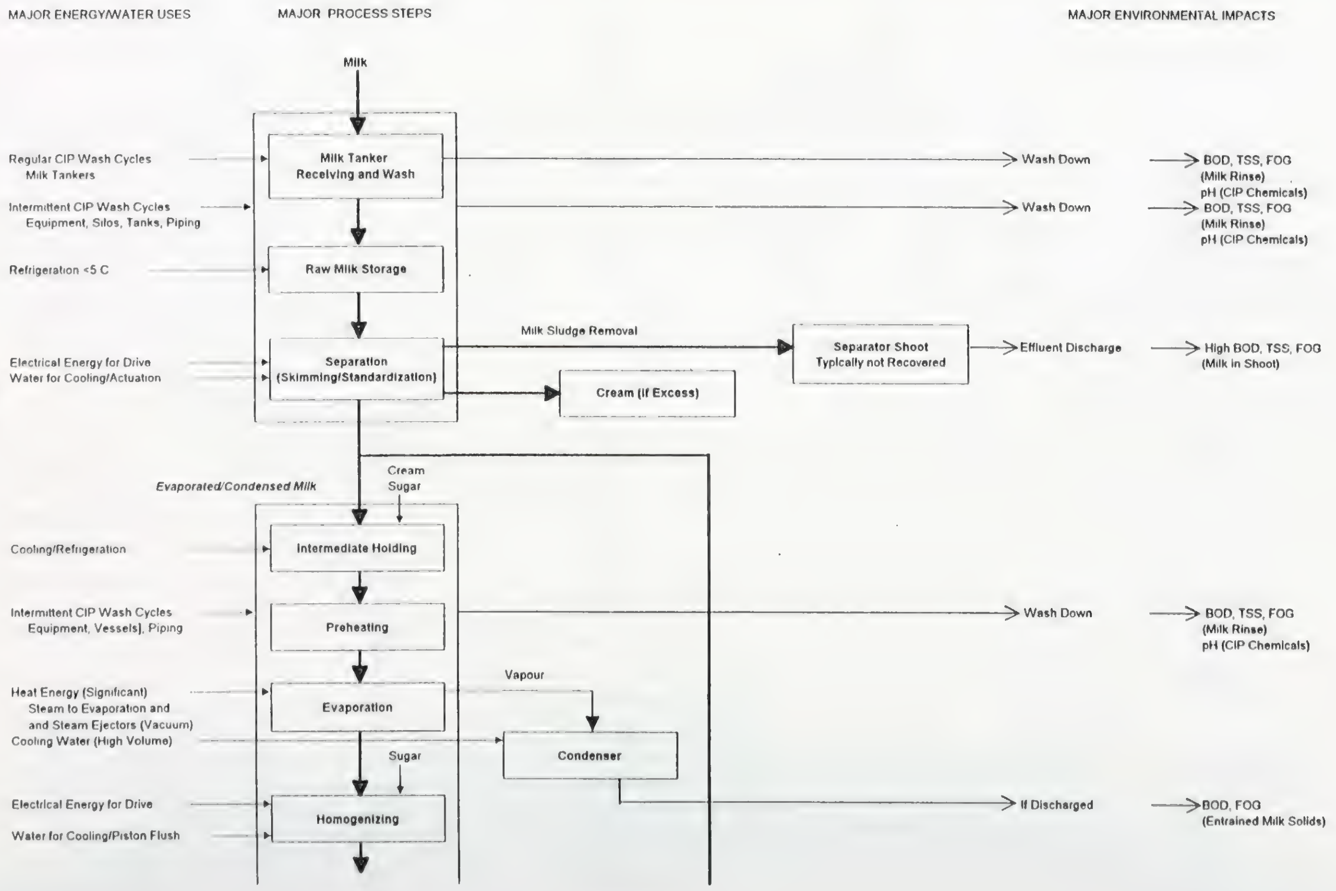
FIGURE 6.5: Process Flow Diagram for Butter Processing

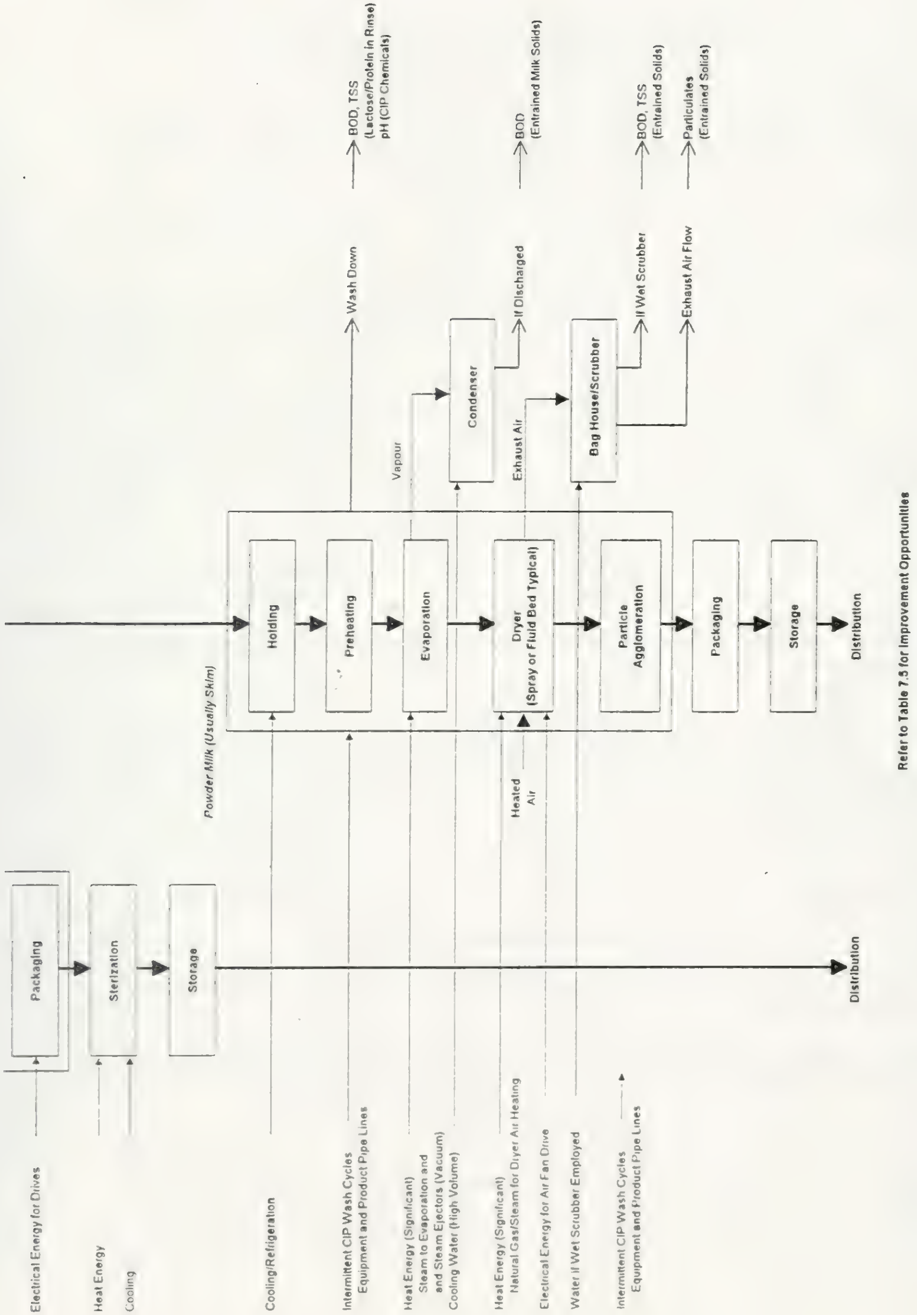

MAJOR ENERGY/WATER USES
MAJOR PROCESS STEPS
MAJOR ENVIRONMENTAL IMPACTS
Milk
Cream (Bulk)
Cream (Cans)
Raw Area
Steady CIP Wash Cycles
Steady CIP Wash Cycles
Milk Tanker Receiving and Wash
Bulk Cream Receiving and Wash
Wash Down
BOD, TSS, FOG (Milk Rinse) pH, TP, TKN (CIP Chemicals)
Intermittent CIP Wash Cycles
Wash Down
BOD, TSS, FOG (Milk Rinses) pH, TP, TKN (CIP Chemicals)
Intermittent CIP Wash Cycles
Refrigeration <5 C
Refrigeration <5 C
Raw Milk Storage
Cream Storage
Wash Down
BOD, TSS, FOG (Cream Rinses) pH, TP, TKN (CIP Chemicals)
Cans
Continuous Wash
Can Wash
Wash Down
BOD, TSS, FOG (Residual Cream Rinses)
Processing/Pasteurization
(Raw Area under DPRIS)
Milk Sludge Removal
Electrical Energy for Drive
Water for Cooling/Actuation
Separation (Centrifuge)
Separator Shoot Typically not Recovered
Effluent Discharge
High BOD, TSS, FOG (Milk in Shoot)
Intermediate Storage
Intermittent CIP Wash Cycles
Heat Energy
Water/Refrigeration/Chilling
Heat Treatment Pasteurization (HTST)
Heat Energy
Water/Refrigeration/Cooling
Heat Treatment Pasteurization (HTST)
Pasteurizer Start-up and Shut-down
BOD, TSS, FOG (Milk)
Wash Down
BOD, TSS, FOG (Milk Rinse) pH, TP, TKN (CIP Chemicals)
Refrigeration <5 C
Skim Milk Storage
Refrigeration
Pasteurize Storage
Intermittent CIP Wash Cycles
Equipment and Transfer Piping
Wash Down
BOD, TSS, FOG (Milk/Cream/Butter Rinse) pH, TP, TKN (CIP Chemicals)
Heat Energy
Heat Treatment



Refer to Table 7.5 for Improvement Opportunities

FIGURE 6.6: Process Flow Diagram for Evaporated/Dried Product Processing


MAJOR ENERGY/WATER USES
MAJOR PROCESS STEPS
MAJOR ENVIRONMENTAL IMPACTS
Milk
Regular CIP Wash Cycles
Milk Tankers
Intermittent CIP Wash Cycles
Equipment, Silos, Tanks, Piping
Refrigeration <5 C
Electrical Energy for Drive
Water for Cooling/Actuation
Milk Tanker Receiving and Wash
Raw Milk Storage
Separation (Skimming/Standardization)
Milk Sludge Removal
Separator Shoot Typically not Recovered
Cream (If Excess)
Wash Down
BOD, TSS, FOG (Milk Rinse) pH (CIP Chemicals)
Wash Down
BOD, TSS, FOG (Milk Rinse) pH (CIP Chemicals)
Effluent Discharge
High BOD, TSS, FOG (Milk in Shoot)
Evaporated/Condensed Milk
Cream
Sugar
Cooling/Refrigeration
Intermediate Holding
Intermittent CIP Wash Cycles
Equipment, Vessels], Piping
Preheating
Wash Down
BOD, TSS, FOG (Milk Rinse) pH (CIP Chemicals)
Heat Energy (Significant)
Steam to Evaporation and
and Steam Ejectors (Vacuum)
Cooling Water (High Volume)
Evaporation
Vapour
Condenser
If Discharged
BOD, FOG (Entrained Milk Solids)
Sugar
Electrical Energy for Drive
Water for Cooling/Piston Flush
Homogenizing


Electrical Energy for Drives
Heat Energy
Cooling
Packaging
Sterlization
Storage
Distribution
Cooling/Refrigeration
Intermittent CIP Wash Cycles
Equipment and Product Pipe Lines
Heat Energy (Significant)
Steam to Evaporation and
and Steam Ejectors (Vacuum)
Cooling Water (High Volume)
Heat Energy (Significant)
Natural Gas/Steam for Dryer Air Heating
Electrical Energy for Air Fan Drive
Water if Wet Scrubber Employed
Intermittent CIP Wash Cycles
Equipment and Product Pipe Lines
Powder Milk (Usually Skim)
Heated
Air
Holding
Preheating
Evaporation
Dryer
(Spray or Fluid Bed Typical)
Particle
Agglomeration
Packaging
Storage
Distribution
Vapour
Exhaust Air
Condenser
Bag House/Scrubber
Wash Down
If Discharged
If Wet Scrubber
Exhaust Air Flow
BOD, TSS
(Lactose/Protein in Rinse)
pH (CIP Chemicals)
BOD
(Entrained Milk Solids)
BOD, TSS
(Entrained Solids)
Particulates
(Entrained Solids)

Refer to Table 7.5 for Improvement Opportunities

TABLE 6-1
TYPICAL UTILITY AND SERVICE REQUIREMENTS FOR DAIRY PROCESSING PLANTS

UTILITY	DEMAND REQUIREMENTS	SPECIFIC PROCESS
Cold Water:		
10°C City	Rinsing, Washing.	All
1-7°C Chilled	Recirculation Cooling, Product Cooling	All
Hot Water:		
90°C	Pasteurizer Heating	All
70°C	Mould Release	Ice Cream
50+°C	Washup/CIP	All
Steam:		
Approx 790 kPa abs	Pasteurizer Heating (usually via Hot Water)	All
	Dryer Air Heating	Dried Product
	Evaporation	Evap/Dried Prod
Lower 790 kPa abs	Water Heating	All
Natural Gas:		
Furnace	Space Heating	All
Boiler	Hot Water/Space Heating	All
Heater	Dryer Air Heating	Dried Product
Refrigeration:		
-40°C	Mould Brine	Ice Cream
-30°C	Freezer/Storage	Ice Cream
-9°C	Ice Cream Maker	Ice Cream
-6°C	Glycol for HTST Chilling	All
1°C	Product Holding Cooler	All
4°C	Milk/Product Cooling	All
Compressed Air	Valve Actuation. Air Blows. Conveying	All
Electrical (Direct Uses)	Conveyor, Centrifuge, Homogenizer, Packaging Unit Drives, Lights, Refrigeration.	All

Note: All = Fluid Milk. Cheese. Ice Cream. Cultured Products. Butter and Evap/Dried

7.0 GENERIC PROCESS IMPROVEMENT OPPORTUNITIES

For each of the six basic processes, a concise generic checklist of process improvement opportunities is provided in the form of a table as follows:

- Fluid Milk Processing - Table 7.1.
- Cheese Processing - Table 7.2.
- Ice Cream and Other Frozen Products - Table 7.3.
- Cultured Products - Table 7.4.
- Butter - Table 7.5.
- Evaporated and Dried Product Processing - Table 7.6.

These checklists will assist in the identification of process related improvement opportunities incorporating energy water efficiency and pollution prevention. Each table covers the same sequence of activities as the generic process diagrams, and provides:

- Identification of thermal, electrical, environmental and water use implications.
- Low cost/no cost measures that can be implemented.
- Applicable retrofit technology options, cross referenced to Table 7.7.
- Comments.

TABLE 7-1: CHECKLIST OF IMPROVEMENT OPPORTUNITIES FOR FLUID MILK PROCESSING

PROCESS AREA	CONCERNS				OPERATING, LOW COST/NO COST	RETROFIT	REF. NO. *	COMMENTS
	Thermal	Power	Environment	Water				
Raw Milk Receiving and Tanker Wash (Raw Area)	Heating required for CIP solution.	Recirculation pump required.	BOD, TSS, FOG from milk in CIP rinse.	Fairly steady CIP operation, with initial and final water rinses.	Ensure proper connections and sealing to minimize leakage.	Selective use of air-blow in raw area for residual product removal.	5	Concerns regarding back contamination. These need to be better addressed to allow broader application
					Allow proper drainage (as much as possible) prior to disconnection	Optical interface unit to monitor milk/water interface.	1	Allows more precise switch-over.
					Reduce tanker hold up to minimize standing time. Standing time allows cream to separate, increasing residual product within tanker.	Optical unit allows use of small water burst to chase milk to silo.	1	
						Exterior Tanker Wash with recycled water from elsewhere in plant.	6	
						CIP System Improvements	See CIP Below	
Raw Milk Holding Silos (Raw Area)	Heating required for CIP solution.	Refrigeration required to maintain at less than 5 C.	BOD, TSS, FOG from milk, and pH from chemical discharges in CIP rinse	Intermittent CIP initial and final rinses.	Allow thorough draining of lines/silos prior to CIP to minimize residual product	Selective use of air-blow in raw area for residual product removal to pasteurization.	5	Concerns of back contamination need to be better addressed for broader application
						Optical interface unit to monitor milk/water interface.	1	Allows more precise switch-over.
Processing and Pasteurization System (Raw Area):	Heating required for CIP solution.		BOD, TSS, FOG from milk in CIP rinse.	Intermittent CIP with initial and final rinses. Large flows per event.	Allow thorough draining of lines/vessels/process equipment prior to CIP to minimize residual product	CIP System Improvements	See CIP Below	
				Pump seal flush flows in area.	Install nozzles or flow restrictions to reduce flushing water flow to minimum - refer to manufacturers recommended requirements.			
Milk Separation and Standardization		Large motor on separator.	Separator discharge - large BOD, TSS, FOG resulting from milk discharged with the sludge.	Operating and cooling water for separator.	Direct shoot to animal feed rather than to sewer.	Auxiliary centrifuge to re-separate milk shoot, recovering milk.	2	
Homogenization		Large motor on homogenizer.		Piston flushing and cooling. See above for CIP.	Install nozzles or flow restrictions to reduce flushing water flow to minimum - refer to manufacturers recommended requirements.			
Pasteurization using High Temperature Short Time (HTST) Plate Heat Exchanger	Heating to 72 C for 16 s hold time required. Heat exchangers incorporate regeneration. 85% to 90% recovery typical.	Final chilling of product to less than 5 C using glycol is required.		Cooling water or recirc chilled water for partial cooling.	Increase maintenance to prevent leakage from plate pack.	Add plates to improve efficiency.	7	Only applicable if unit can be expanded. Likely only economic if existing regen is relatively low.
					Minimize start-up and shut-down loss volume			
Pasteurized Milk Storage (Pasteurized Area)	Heating required for CIP solution	Refrigeration required to maintain product at 5 C.	BOD, TSS, FOG from milk in CIP rinse.	Intermittent CIP with initial and final rinses. Large flows per event.	Allow thorough draining of lines/vessels prior to CIP to minimize residual product.	CIP System Improvements	See CIP Below	

Product Conveying, Filling and Casing (Pasteurized Area)	Heating required for CIP solution	Filling system drives	BOD, TSS, FOG from milk in CIP rinse.	Intermittent CIP with initial and final rinses. Large flows per event.	Minimize product loss during change-overs and shutdowns by continuing to fill to packages, holding them aside. Product can be recovered for rework or employed for animal feed.	Optical interface unit to monitor milk/water interface for rinse out.	1	Allows more precise switch over.
					Schedule product runs to minimize change-over washing. (e.g. white, white, chocolate, rather than white, chocolate, white).	Active bacterial control in filling area to help enhance shelf life	4	
		Conveyor system drives.	BOD from conveyor lubricant (soap) sprays	Conveyor sprays	Ensure use of nozzles on all flushing flows. Review type and positioning of spray nozzles.	CIP System Improvements	See CIP Below	
Case Washing	Heating of solution for wash flow required	Conveyor system drives	BOD, TSS from debris. pH from wash solution	Water to case wash sprays		Recycle water from elsewhere in plant for initial case wash flush.	6	
Product Storage		Refrigeration required to maintain cooler at 1 C				Free Cooling during Winter months	8	
CIP Operations	Heating required for CIP solution	Recirculation pumps	BOD, TSS, FOG from milk in CIP rinse. 90% of the residual BOD in the tank is removed in the first burst rinses. pH, TP and TKN from chemical discharges in CIP.	Initial and final water rinses. CIP solutions makeup.	Use volume, rather than time, based control on burst rinses.	Optical interface unit to monitor milk/rinse water interface and water/CIP chemical interface	1	Allows more precise switch over
						Collection of potable water initial rinses from CIP systems and re concentration of milk solids using membrane technology	3	Collected milk solids can be concentrated to higher level than normal milk and potentially utilized in industrial products.
						Recycle system on HTST washing chemicals, especially phosphoric acid	9	Most areas of plants incorporate recycle of chemicals for CIP. Recycle of HTST wash chemicals may be possible if this is not already being done.
Washup throughout plant	Warm water (<48 C) often employed to solubilize butterfat		BOD, TSS, FOG in washup water	Water for washup	Install nozzles on hoses. Do not leave water running when not required. Treat dry ingredient spills as solid wastes, rather than flushing with water. Hoses should not be used as brooms. Use heated water or heat exchange rather than steam injection for heating Use dose sized dispensers for manual cleaners (e.g. dose sized scoops for powders) to reduce overuse. "More is not better" Encourage prompt reporting of leaks to ensure chronic leakage problems addressed.			
Effluent Monitoring						In line continuous BOD monitor.	10	
Solid Waste					Ensure aware of and utilize local recycling infrastructure.			

* NOTE: SEE TABLE 7-7 FOR FURTHER DESCRIPTION OF RETROFITS BY REFERENCE NUMBER

TABLE 7-2: CHECKLIST OF IMPROVEMENT OPPORTUNITIES FOR CHEDDAR CHEESE PROCESSING

PROCESS AREA	CONCERNS				OPERATING, LOW COST/NO COST	RETROFIT	REF. NO. *	COMMENTS
	Thermal	Power	Environment	Water				
Raw Milk Receiving and Tanker Wash (Raw Area)	Heating required for CIP solution.	Recirculation pump required.	BOD, TSS, FOG from milk in CIP rinse.	Fairly steady CIP operation, with initial and final water rinses.	Ensure proper connections and sealing to minimize leakage.	Selective use of air-blow in raw area for residual product removal.	5	Concerns regarding back contamination. These need to be better addressed to allow broader application
					Allow proper drainage (as much as possible) prior to disconnection	Optical interface unit to monitor milk/water interface.	1	Allows more precise switch-over.
					Reduce tanker hold-up to minimize standing time. Standing time allows cream to separate, increasing residual product within tanker.	Optical unit allows use of small water burst to chase milk to silo.	1	
						Exterior Tanker Wash with recycled water from elsewhere in plant.	6	
						CIP System Improvements	See CIP Below	
Raw Milk Holding Silos (Raw Area)	Heating required for CIP solution.	Refrigeration required to maintain at less than 5 C.	BOD, TSS, FOG from milk, and pH from chemical discharges in CIP rinse.	Intermittent CIP initial and final rinses.	Allow thorough draining of lines/silos prior to CIP to minimize residual product	Selective use of air-blow in raw area for residual product removal to pasteurization.	5	Concerns of back contamination need to be better addressed for broader application
						Optical interface unit to monitor milk/water interface.	1	Allows more precise switch-over.
Processing and Pasteurization System (Raw Area):	Heating required for CIP solution.		BOD, TSS, FOG from milk in CIP rinse.	Intermittent CIP with initial and final rinses. Large flows per event.	Allow thorough draining of lines/vessels/process equipment prior to CIP to minimize residual product	CIP System Improvements	See CIP Below	
				Pump seal flush flows in area.	Install nozzles or flow restrictions to reduce flushing water flow to minimum - refer to manufacturers recommended requirements.			
Milk Separation and Standardization		Large motor on separator.	Separator discharge - large BOD, TSS, FOG from milk discharged with sludge.	Operating and cooling water for separator.	Direct shoot to animal feed rather than to sewer.	Auxilliary centrifuge to re-separate milk shoot, recovering milk.	2	
Heat Treatment. High Temperature Short Time (HTST) Plate Heat Exchanger	Heating to 72 C for 16 s hold time required. Heat exchangers incorporate regeneration. 85% to 90% recovery typical.				Increase maintenance to prevent leakage from plate-pack.	Add plates to improve efficiency.	7	Only applicable if unit can be expanded. Likely only economic if existing regen is relatively low.
					Minimize start-up and shut-down loss volume			
Cheese Vat Processing Area (Pasteurized Area)	Heating required for CIP solution. Heating required during cooking operations	Vat drives (stirring and cutting)	BOD, TSS, from milk in CIP rinse and whey drainage	Intermittent CIP with initial and final rinses.	If manually filled, increase operator supervision of vat level to prevent over filling.	Install automated filling control to eliminate over-filling.	11	Proper handling of whey important to minimize effluent BOD.
					Treat curd spills as solid wastes, rather than flushing with water.			

Block Formation		Pressing	BOD, TSS from whey drainage.		Treat cheese spillage as solid waste rather than flushing with water.			Handling of whey important to minimize effluent BOD.
Hoop Washing	Heating of wash solution required		BOD, TSS from residual cheese and whey	Water flush				
Aging/Product Storage		Refrigeration required to maintain at 2-10 C				Implement free Cooling during Winter months	8	
Whey Processing (for Whey Powder - most common)	Large thermal load in Evaporation	Pumps	High BOD of whey	Large cooling water load at condenser	Ensure all whey collected, and do not allow to escape to effluent.	Preconcentration using membranes	12	Also reduces transportation volumes for smaller plants.
CIP Operations	Heating required for CIP solution	Recirculation pumps.	BOD, TSS, FOG from milk in CIP rinse. 90% of the residual BOD in the tank is removed in the first burst rinses. pH, TP and TKN from chemical discharges in CIP.	Initial and final water rinses. Makeup to CIP solutions.	Use volume, rather than time, based control on burst rinses.	Optical interface unit to monitor milk/rinse water interface and water/CIP chemical interface	1	Allows more precise switch over
					Use hot Evaporator condensate for the Initial rinse, and potable water for the final rinse.	Collection of potable water initial rinses from CIP systems and re-concentration of milk solids using membrane technology.	3	Collected milk solids can be concentrated to higher level than normal milk and potentially utilized in Industrial products.
						Recycle system on HTST washing chemicals, especially phosphoric acid.	9	Most areas of plants incorporate recycle of chemicals for CIP. Recycle of HTST wash chemicals may be possible if this is not already being done.
Washup throughout plant	Warm water (< 46 C) often employed to solubilize butterfat		BOD, TSS, FOG in washup water.	Water for washup	Install nozzles on hoses. Do not leave water running when not required. Treat dry ingredient spills as solid wastes, rather than flushing with water. Hoses should not be used as brooms. Use heated water or heat exchange rather than steam injection for heating. Use dose-sized dispensers for manual cleaners (e.g. dose-sized scoops for powders) to reduce overuse. "More is not better". Encourage prompt reporting of leaks to ensure chronic leakage problems addressed.			
Effluent Monitoring						In-line continuous BOD monitor.	10	
Solid Waste					Ensure aware of and utilize local recycling infrastructure.			

* NOTE: SEE TABLE 7-7 FOR FURTHER DESCRIPTION OF RETROFITS BY REFERENCE NUMBER

TABLE 7-3: CHECKLIST OF IMPROVEMENT OPPORTUNITIES FOR ICE CREAM AND FROZEN PRODUCTS PROCESSING

PROCESS	CONCERNS				OPERATING,	RETROFIT	REF.	COMMENTS
AREA	Thermal	Power	Environment	Water	LOW COST/NO COST		NO. *	
Raw Milk Receiving and Tanker Wash (Raw Area)	Heating required for CIP solution.	Recirculation pump required.	BOD, TSS, FOG from milk in CIP rinse.	Fairly steady CIP operation, with initial and final water rinses.	Ensure proper connections and sealing to minimize leakage.	Selective use of air-blow in raw area for residual product removal.	5	Concerns regarding back contamination. These need to be better addressed to allow broader application
					Allow proper drainage (as much as possible) prior to disconnection	Optical interface unit to monitor milk/water interface	1	Allows more precise switch-over.
					Reduce tanker hold-up to minimize standing time. Standing time allows cream to separate, increasing residual product within tanker.	Optical unit allows use of small water burst to chase milk to silo	1	
						Exterior Tanker Wash with recycled water from elsewhere in plant.	6	
						CIP System Improvements	See CIP Below	
Raw Milk and Cream Holding (Raw Area)	Heating required for CIP solution	Refrigeration required to maintain at less than 5 C	BOD, TSS, FOG from milk, and pH from chemical discharges in CIP rinse	Intermittent CIP initial and final rinses.	Allow thorough draining of lines/silos prior to CIP to minimize residual product	Selective use of air blow in raw area for residual product removal to pasteurization	5	Concerns of back contamination need to be better addressed for broader application
						Optical interface unit to monitor milk/water interface.	1	Allows more precise switch over
Ice Cream Milk Blending (Raw Area)					Treat dry ingredient spills as solid wastes, rather than flushing with water. Hoses should not be used as brooms.			
Processing and Pasteurization System (Raw Area):	Heating required for CIP solution.		BOD, TSS, FOG from milk in CIP rinse.	Intermittent CIP with initial and final rinses. Large flows per event.	Allow thorough draining of lines/vessels/process equipment prior to CIP to minimize residual product	CIP System Improvements	See CIP Below	
				Pump seal flush flows in area.	Install nozzles or flow restrictions to reduce flushing water flow to minimum - refer to manufacturers recommended requirements.			
Homogenization		Large motor on homogenizer		Piston flushing and cooling. See above for CIP.	Install nozzles or flow restrictions to reduce flushing water flow to minimum - refer to manufacturers recommended requirements.			
Pasteurization using High Temperature Short Time (HTST) Plate Heat Exchanger	Heating to 72 C for 16 s hold time required. Heat exchangers incorporate regeneration. 85% to 90% recovery typical.	Final chilling of product to less than 5 C using glycol is required.		Cooling water or recirc chilled water for partial cooling.	Increase maintenance to prevent leakage from plate pack.	Add plates to improve efficiency.	7	Only applicable if unit can be expanded. Likely only economic if existing regen is relatively low.
					Minimize start-up and shut-down loss volume			
Pasteurized Ice Cream Mix Storage (Pasteurized Area)	Heating required for CIP solution.	Refrigeration required to maintain product at 5 C.	BOD, TSS, FOG from milk in CIP rinse.	Intermittent CIP with initial and final rinses. Large flows per event.	Allow thorough draining of lines/vessels/process equipment prior to CIP to minimize residual product	CIP System Improvements	See CIP Below	

Bulk Ice Cream Production filling	Heating required for CIP solution	Freezing unit refrigeration and drives. Filling system pump drives.	BOD, TSS, FOG from milk in CIP rinse	Intermittent CIP with initial and final rinses. Large flows per event.	Collect residual ice cream mix for rework Treat ice cream spillage at filling as solid waste and collect into separate containers, rather than flushing with water	Use small burst initial burst rinses, collecting slightly diluted ice cream mix for inclusion in rework	13	
Ice Cream/Novelty Moulding	Heated water for mould release	Refrigeration of mould brine at -40 C; Mould conveyor drive.	BOD, TSS, FOG from mould flush. pH from some products (e.g. fruit flavoured popsicle mixes)	Sprays of water to release frozen novelties from moulds.	Ensure proper water flow controls for mould cleaning to ensure water use not excessive. Ensure maintenance of brine temperature and control warmup to avoid excess sticking in moulds Ensure warmup well controlled to avoid excessive melting Encourage operator attention to avoid jamming of sticks into bars.			
Product Freezer		Refrigeration required to maintain cooler at -30 C.						
CIP Operations	Heating required for CIP solution	Recirculation pumps.	BOD, TSS, FOG from milk in CIP rinse. 90% of the residual BOD in the tank is removed in the first burst rinses. pH, TP and TKN from chemical discharges in CIP	Initial and final water rinses. Makeup to CIP solutions.	Use volume, rather than time, based control on burst rinses.	Collection of potable water initial rinses from CIP systems and reconcentration of milk solids using membrane technology Recycle system on HTST washing chemicals, especially phosphoric acid	3 9	Collected milk solids can be concentrated to higher level than normal milk and potentially utilized in Industrial products Most areas of plants incorporate recycle of chemicals for CIP. Recycle of HTST wash chemicals may be possible if this is not already being done.
Washup throughout plant	Warm water (<46 C) often employed to solubilize butterfat		BOD, TSS, FOG from washups	Water for washup	Install nozzles on hoses. Do not leave water running when not required. Treat dry ingredient spills as solid wastes, rather than flushing with water. Hoses should not be used as brooms. Use heated water or heat exchange rather than steam injection for heating. Use dose sized dispensers for manual cleaners (e.g. dose-sized scoops for powders) to reduce overuse. "More is not better". Encourage prompt reporting of leaks to ensure chronic leakage problems addressed.			
Effluent Monitoring						In line continuous BOD monitor.	10	
Solid Waste					Ensure aware of and utilize local recycling infrastructure.			

* NOTE: SEE TABLE 7-7 FOR FURTHER DESCRIPTION OF RETROFITS BY REFERENCE NUMBER

TABLE 7-4: CHECKLIST OF IMPROVEMENT OPPORTUNITIES CULTURED PRODUCT PROCESSING

PROCESS AREA	CONCERNS				OPERATING, LOW COST/NO COST	RETROFIT	REF NO *	COMMENTS
	Thermal	Power	Environment	Water				
Raw Milk Receiving and Tanker Wash (Raw Area)	Heating required for CIP solution	Recirculation pump required.	BOD, TSS, FOG from milk in CIP rinse	Fairly steady CIP operation, with initial and final water rinses	Ensure proper connections and sealing to minimize leakage.	Selective use of air blow in raw area for residual product removal	5	Concerns regarding back contamination. These need to be better addressed to allow broader application
					Allow proper drainage (as much as possible) prior to disconnection	Optical interface unit to monitor milk/water interface	1	Allows more precise switch over
					Reduce tanker hold up to minimize standing time. Standing time allows cream to separate, increasing residual product within tanker	Optical unit allows use of small water burst to chase milk to silo	1	
						Exterior Tanker Wash with recycled water from elsewhere in plant	6	
						CIP System Improvements	See CIP Below	
Raw Milk Holding Silos (Raw Area)	Heating required for CIP solution	Refrigeration required to maintain at less than 5 C	BOD, TSS, FOG from milk, and pH from chemical discharges in CIP rinse	Intermittent CIP initial and final rinses.	Allow thorough draining of lines/silos prior to CIP to minimize residual product	Selective use of air blow in raw area for residual product removal to pasteurization	5	Concerns of back contamination need to be better addressed for broader application
						Optical interface unit to monitor milk/water interface.	1	Allows more precise switch over
Processing and Pasteurization System (Raw Area)	Heating required for CIP solution		BOD, TSS, FOG from milk in CIP rinse	Intermittent CIP with initial and final rinses. Large flows per event	Allow thorough draining of lines/vessels/process equipment prior to CIP to minimize residual product	CIP System Improvements	See CIP Below	
				Pump seal flush flows in area.	Install nozzles or flow restrictions to reduce flushing water flow to minimum - refer to manufacturers recommended requirements.			
Milk Separation and Standardization		Large motor on separator.	Separator discharge - large BOD, TSS, FOG resulting from milk discharged with the sludge	Operating and cooling water for separator.	Direct shoot to animal feed rather than to sewer	Auxiliary centrifuge to re-separate milk shoot, recovering milk	2	
Homogenization		Large motor on homogenizer		Piston flushing and cooling. See above for CIP	Install nozzles or flow restrictions to reduce flushing water flow to minimum - refer to manufacturers recommended requirements			
Pasteurization using High Temperature Short Time (HTST) Plate Heat Exchanger	Heating to 72 C for 16 s hold time required. Heat exchangers incorporate regeneration. 85% to 90% recovery typical	Final chilling of product to less than 5 C using glycol is required		Cooling water or recirc chilled water for partial cooling	Increase maintenance to prevent leakage from plate pack	Add plates to improve efficiency	7	Only applicable if unit can be expanded. Likely only economic if existing regen is relatively low
					Minimize start-up and shut-down loss volume			
Pasteurized Product Storage (Pasteurized Area)	Heating required for CIP solution	Refrigeration required to maintain product at 5 C.	BOD, TSS, FOG from milk in CIP rinse.	Intermittent CIP with initial and final rinses. Large flows per event.	Allow thorough draining of lines/vessels prior to CIP to minimize residual product.	CIP System Improvements	See CIP Below	
Bulk Starter Culture	Heating required for incubation. Heating required for CIPsolution		BOD, TSS, FOG from milk in CIP rinse.	Intermittent CIP with initial and final rinses		CIP System Improvements	See CIP Below	
						Active bacterial control in starter culture area to help reduce potential contamination	4	

Main Culture Incubation/Holding	Heating required for incubation. Heating required for CIPsolution		BOD, TSS, FOG from milk in CIP rinse	Intermittent CIP with initial and final rinses. Large flows per event. Viscosity a concern causing increased		CIP System Improvements	See CIP Below	
						Active bacterial control in incubation area to help reduce potential contamination	4	
Cooling		Refrigeration for cooling						
Filling/Cartoning/Casing	Heating required for CIP solution	Filling system drives	BOD, TSS, FOG from milk in CIP rinse. Residual more a concern for higher viscosity Stirred product than for Set	Intermittent CIP with initial and final rinses. Large flows per event	Minimize product loss during change overs and shutdowns by continuing to fill to packages, holding them aside. Product can be recovered for rework or employed for animal feed	Optical interface used to monitor milk/water interface for rinse out	1	Allows more precise switch over
					Schedule product runs to minimize change over washing	Active bacterial control in filling area to help enhance shelf life	4	
		Conveyor system drives	BOD from conveyor lubricant (soap) sprays.	Conveyor sprays	Ensure use of nozzles on all flushing flows. Review type and positioning of spray nozzles.	CIP System Improvements	See CIP Below	
Product Storage		Refrigeration required to maintain cooler at 1 C				Free Cooling during Winter months	8	
CIP Operations	Heating required for CIP solution	Recirculation pumps	BOD, TSS, FOG from milk in CIP rinse. 90% of the residual BOD in the tank is removed in the first burst rinses. pH, TP and TKN from	Initial and final water rinses. CIP solutions makeup	Use volume, rather than time, based control on burst rinses	Optical interface used to monitor milk/rinse water interface and water/CIP chemical interface	1	Allows more precise switch over
						Collection of potable water initial rinses from CIP systems and re concentration of milk solids using membrane technology	3	Collected milk solids can be concentrated to higher level than normal milk and potentially utilized in industrial products
						Recycle system on HTST washing chemicals, especially phosphoric acid	9	Most areas of plants incorporate recycle of chemicals for CIP. Recycle of HTST wash chemicals may be possible if this is not already being done
Washup throughout plant	Warm water (< 48 C) often employed to solubilize butterfat		BOD, TSS, FOG in washup water	Water for washup	Install nozzles on hoses. Do not leave water running when not required Treat dry ingredient spills as solid wastes, rather than flushing with water. Hoses should not be used as brooms Use heated water or heat exchange rather than steam injection for heating Use dose-sized dispensers for manual cleaners (e.g. dose sized scoops for powders) to reduce overuse. "More is not better" Encourage prompt reporting of leaks to ensure chronic leakage problems addressed.			
Effluent Monitoring						In line continuous BOD monitor.	10	
Solid Waste					Ensure aware of and utilize local recycling infrastructure.			

* NOTE: SEE TABLE 7.7 FOR FURTHER DESCRIPTION OF RETROFITS BY REFERENCE NUMBER

TABLE 7-5: CHECKLIST OF IMPROVEMENT OPPORTUNITIES FOR BUTTER PROCESSING

PROCESS AREA	CONCERNS				OPERATING, LOW COST/NO COST	RETROFIT	REF. NO. *	COMMENTS
	Thermal	Power	Environment	Water				
Bulk Raw Milk and Cream Receiving and Tanker Wash (Raw Area)	Heating required for CIP solution.	Recirculation pump required.	BOD, TSS, FOG from milk in CIP rinse.	Fairly steady CIP operation, with initial and final water rinses.	Ensure proper connections and sealing to minimize leakage.	Selective use of air-blow in raw area for residual product removal.	5	Concerns regarding back contamination. These need to be better addressed to allow broader application
					Allow proper drainage (as much as possible) prior to disconnection	Optical interface unit to monitor milk/water interface.	1	Allows more precise switch-over.
					Reduce tanker hold-up to minimize standing time. Standing time allows cream to separate, increasing residual product within tanker.	Optical unit allows use of small water burst to chase milk to silo.	1	
						Exterior Tanker Wash with recycled water from elsewhere in plant.	6	
						CIP System Improvements	See CIP Below	
Can Washing (Raw Area)	Heating required for water flow to can washing	Conveyor drive.	BOD, TSS, FOG from Can residuals	Water flow to washer.	Use volume control rather than time control in can washing.			
Raw Milk and Cream Holding Tanks (Raw Area)	Heating required for CIP solution.	Refrigeration required to maintain at less than 5 C.	BOD, TSS, FOG from milk, and pH from chemical discharges in CIP rinse.	Intermittent CIP initial and final rinses.	Allow thorough draining of lines/silos prior to CIP to minimize residual product	Selective use of air-blow in raw area for residual product removal to pasteurization.	5	Concerns of back contamination need to be better addressed for broader application
						Optical interface unit to monitor milk/water interface.	1	Allows more precise switch-over.
Processing and Pasteurization System (Raw Area):	Heating required for CIP solution.		BOD, TSS, FOG from milk in CIP rinse.	Intermittent CIP with initial and final rinses. Large flows per event.	Allow thorough draining of lines/vessels/process equipment prior to CIP to minimize residual product	CIP System Improvements	See CIP Below	
				Pump seal flush flows in area.	Install nozzles or flow restrictions to reduce flushing water flow to minimum - refer to manufacturers recommended requirements.			
Cream Separation from Milk		Large motor on separator.	Separator discharge - large BOD, TSS, FOG resulting from milk discharged with sludge.	Operating and cooling water for separator.	Direct shoot to animal feed rather than to sewer.	Auxilliary centrifuge to reseparate milk shoot, recovering milk.	2	
Pasteurization using High Temperature Short Time (HTST) Plate Heat Exchanger	Heating to 72 C for 16 s hold time required. Heat exchangers incorporate regeneration. 85% to 90% recovery typical.	Final chilling of product to less than 5 C using glycol is required.		Cooling water or recirc chilled water for partial cooling.	Increase maintenance to prevent leakage from plate-pack.	Add plates to improve efficiency.	7	Only applicable if unit can be expanded. Likely only economic if existing regen is relatively low.
					Minimize start-up and shut-down loss volume			
Pasteurized Skim Milk Storage (Pasteurized Area)	Heating required for CIP solution.	Refrigeration required to maintain product at 5 C.	BOD, TSS, FOG from milk in CIP rinse.	Intermittent CIP with initial and final rinses. Large flows per event.	Allow thorough draining of lines/vessels prior to CIP to minimize residual product.	CIP System Improvements	See CIP Below	

Churning / Butter Making	Heating required for CIP solution	Drives for butter production.	BOD, TSS, FOG from milk in CIP rinse	Intermittent CIP with initial and final rinses.		CIP System Improvements	See CIP Below	
Forming / Packaging / Cartoning and Palletizing	Heating required for CIP solution flow in forming/packaging.	Drives for butter production.	BOD, TSS, FOG from milk in CIP rinse.	Intermittent CIP with initial and final rinses.		CIP System Improvements	See CIP Below	
Product Storage		Refrigeration required to maintain cooler				Free Cooling during Winter months.	8	
CIP Operations	Heating required for CIP solution	Recirculation pumps.	BOD, TSS, FOG from milk in CIP rinse. 90% of the residual BOD in the tank is removed in the first burst rinses. pH, TP and TKN from chemical discharges in CIP.	Initial and final water rinses. CIP solutions makeup.	Use volume, rather than time, based control on burst rinses.	Optical interface unit to monitor milk/rinse water interface and water/CIP chemical interface	1	Allows more precise switch-over.
					Use of Melt Pots to collect fat off equipment	Collection of potable water initial rinses from CIP systems and separation of butterfat using auxilliary centrifuge.	2	
						Collection of potable water initial rinses from CIP systems and reconcentration of milk solids using membrane technology.	3	Collected milk solids can be concentrated to higher level than normal milk and potentially utilized in industrial products.
						Recycle system on HTST washing chemicals, especially phosphoric acid.	9	Most areas of plants incorporate recycle of chemicals for CIP. Recycle of HTST wash chemicals may be possible if this is not already being done.
Washup throughout plant	Warm water (< 46 C) often employed to solubilize butterfat		BOD, TSS, FOG in washup water.	Water for washup	Install nozzles on hoses. Do not leave water running when not required. Treat dry ingredient spills as solid wastes, rather than flushing with water. Hoses should not be used as brooms. Use heated water or heat exchange rather than steam injection for heating. Use dose-sized dispensers for manual cleaners (e.g. dose-sized scoops for powders) to reduce overuse. "More is not better". Encourage prompt reporting of leaks to ensure chronic leakage problems addressed.			
Effluent Monitoring						In-line continuous BOD monitor.	10	
Solid Waste					Ensure aware of and utilize local recycling infrastructure.			

* NOTE: SEE TABLE 7-7 FOR FURTHER DESCRIPTION OF RETROFITS BY REFERENCE NUMBER

TABLE 7-6: CHECKLIST OF IMPROVEMENT OPPORTUNITIES FOR EVAPORATED/DRIED MILK PROCESSING

PROCESS AREA	CONCERNS				OPERATING, LOW COST/NO COST	RETROFIT	REF. NO. *	COMMENTS
	Thermal	Power	Environment	Water				
Raw Milk Receiving and Tanker Wash (Raw Area)	Heating required for CIP solution.	Recirculation pump required.	BOD, TSS, FOG from milk in CIP rinse.	Fairly steady CIP operation, with initial and final water rinses.	Ensure proper connections and sealing to minimize leakage.	Selective use of air-blow in raw area for residual product removal.	5	Concerns regarding back contamination. These need to be better addressed to allow broader application
					Allow proper drainage (as much as possible) prior to disconnection	Optical interface unit to monitor milk/water interface.	1	Allows more precise switch-over.
					Reduce tanker hold-up to minimize standing time. Standing time allows cream to separate, increasing residual product within tanker.	Optical unit allows use of small water burst to chase milk to silo.	1	
						Exterior Tanker Wash with recycled water from elsewhere in plant.	6	
						CIP System Improvements	See CIP Below	
Raw Milk Holding Silos (Raw Area)	Heating required for CIP solution.	Refrigeration required to maintain at less than 5 C.	BOD, TSS, FOG from milk, and pH from chemical discharges in CIP rinse.	Intermittent CIP initial and final rinses.	Allow thorough draining of lines/silos prior to CIP to minimize residual product	Selective use of air-blow in raw area for residual product removal to pasteurization.	5	Concerns of back contamination need to be better addressed for broader application
						Optical Interface unit to monitor milk/water interface.	1	Allows more precise switch-over.
Processing and Pasteurization System (Raw Area):	Heating required for CIP solution.		BOD, TSS, FOG from milk in CIP rinse.	Intermittent CIP with initial and final rinses. Large flows per event.	Allow thorough draining of lines/vessels/process equipment prior to CIP to minimize residual product	CIP System Improvements	See CIP Below	
				Pump seal flush flows in area.	Install nozzles or flow restrictions to reduce flushing water flow to minimum - refer to manufacturers recommended requirements.			
Separation and Standardization		Large motor on separator.	Separator discharge - large BOD, TSS, FOG resulting from milk discharged with the sludge.	Operating and cooling water for separator.	Direct shoot to animal feed rather than to sewer.	Auxiliary centrifuge to re-separate milk shoot, recovering milk.	2	
Pasteurized Milk Storage (Pasteurized Area)	Heating required for CIP solution	Refrigeration required to maintain product at 5 C.	BOD, TSS, FOG from milk in CIP rinse.	Intermittent CIP with initial and final rinses. Large flows per event.	Allow thorough draining of lines/vessels prior to CIP to minimize residual product.	CIP System Improvements	See CIP Below	
Evaporation	Large thermal load for evaporation		BOD, TSS, FOG in condensed vapour	Large cooling water for condenser		Membrane RO/NF preconcentration to reduce thermal load	12	
Post Evaporation Homogenization of Evap/Condensed Product		Large motor on homogenizer.		Piston flushing and cooling. See above for CIP.	Install nozzles or flow restrictions to reduce flushing water flow to minimum - refer to manufacturers recommended requirements.			

Filling, Product Conveying and Casing (Pasteurized Area)	Heating required for CIP solution.	Filling system drives	BOD, TSS, FOG from milk in CIP rinse.	Intermittent CIP with initial and final rinses		Optical Interface unit to monitor milk/water interface for rinse out	1	Allows more precise switch-over.
Post-Filling Sterilization	Large thermal load for sterilization			Cooling water for cooling				
Drying and Agglomeration Spray and Fluid Bed	Large thermal load to heat drying air stream		BOD in wet scrubber flow. Potential particulate emission in air exhaust.	Water to wet scrubber				
CIP Operations	Heating required for CIP solution	Recirculation pumps.	BOD, TSS, FOG from milk in CIP rinse. 90% of the residual BOD in the tank is removed in the first burst rinses. pH, TP and TKN from chemical discharges in CIP.	Initial and final water rinses. CIP solutions makeup.	Use volume, rather than time, based control on burst rinses.	Optical interface unit to monitor milk/rinse water interface and water/CIP chemical interface	1	Allows more precise switch-over
						Collection of potable water initial rinses from CIP systems and re-concentration of milk solids using membrane technology.	3	Collected milk solids can be concentrated to higher level than normal milk and potentially utilized in industrial products.
Washup throughout plant	Warm water (< 48 C) often employed to solubilize butterfat		BOD, TSS, FOG in washup water.	Water for washup	Install nozzles on hoses. Do not leave water running when not required. Treat dry ingredient spills as solid wastes, rather than flushing with water. Hoses should not be used as brooms. Use heated water or heat exchange rather than steam injection for heating. Use dose-sized dispensers for manual cleaners (e.g. dose-sized scoops for powders) to reduce overuse. "More is not better". Encourage prompt reporting of leaks to ensure chronic leakage problems addressed.			
Effluent Monitoring						In-line continuous BOD monitor.	10	
Solid Waste					Ensure aware of and utilize local recycling infrastructure.			

* NOTE: SEE TABLE 7-7 FOR FURTHER DESCRIPTION OF RETROFITS BY REFERENCE NUMBER

TABLE 7-7 CHECKLIST OF RETROFIT OPTIONS FOR DAIRY PRODUCTS PROCESSING

REF NO.	RETROFIT	EQUIPMENT	COSTS	SAVINGS	PAYBACK	COMMENTS/ BENEFITS
1	Product/Water/Chemical Interfaces	Optical Interface Detection Unit	8-12k	3-12k	1-3 yrs	Units tied to controls to initiate switch-overs during CIP and process operations. Reduces product losses, water flow requirements and chemical losses in CIP Also can act for detection of cross-contamination.
2	Recovery of Excess Milk lost with Separator Shoot	Small High "g" Auxilliary Separator to Recentrifuge Milk Shoot	75-125k	25-50k	1-4 yrs	Dilution of shoot with operating and cooling water means can only recover milk if reconcentrating. Recovered sludge direction to animal feed possible
3	Reconcentration of Milk Solids in Potable Water First Rinses from CIP Operations	Rinse Collection and Membrane Systems for Reconcentration	500-800k	150-500k	2-4 yrs	Recovered product usable for Industrial applications. Concentration can be raised to higher than that of Fluid milk.
4	Active bacterial control in production and other areas. (Already used selectively, such as within filling units).	UV Lamp sets or units	0.2-2k	0.1-1k	1-2 yrs	UV lamps have been used, but with limited success. Success depends on unit design and ongoing maintenance.
5	Removing residual product prior to water flush	Air blow				Problem of back-contamination from residual milk into air lines. Broader application may require additional engineering to prevent back-contamination.
6	Washing duties not requiring potable water, including milk tanker exteriors and initial case washing.	Use of recovered secondary water from other relatively clean uses (e.g. CIP post-rinses).				DPRIS considerations for tankers apply to washing of product contact surfaces. Holding tanks, piping and pumps for recovered water. Filtration may be required.
7	Improving HTST regeneration efficiency	Addition of plates, reconfiguration				
8	Reduced active chilling of coolers during Winter months.	Free cooling (during Winter months)	50-150k	20-80k	1-3 yrs	
9	Reduction of cleaning chemicals to effluent. pH, TKN and especially TP	Recycle of HTST chemicals, especially phosphoric acid	20-40k	10-20k	1-3 yrs	HTST large user of phorphoric acid for milk-stone removal.
10	Continuous measurement of effluent BOD.	In-line continuous BOD probe. (Currently being adopted by Pulp and Paper sector)	60-100k			Potential correlation of effluent BOD with process events. Uncertain payback for device. Simpler approaches may be possible using COD or TOC as surrogate for BOD.
11	Control of Cheese Vat filling to eliminate over-fill	Automatic control				
12	Reduction of thermal requirements for Whey or Milk product evaporation	Membrane RO/NF preconcentration	50-200k	50-100k	2-4 yrs	Reduction of thermal requirements. Could be employed by smaller plants to reduce transport volumes.
13	Collection of additional residual ice cream mix from rinsing	Small initial burst rinses of water collecting slightly diluted mixes for rework				

In Table 7-7, the retrofit options applicable to direct process improvements are summarized and categorized into 13 technology groups. For each, a range of probable capital costs, probable savings and resulting paybacks are presented. Each of these technology groups is generic. Information presented should be only used as a guide for assessing applicability and viability at specific plants. Minor capital equipment items, such as nozzles and hose valves, are identified as such in Table 7-1 through 7-6.

A checklist of generic utility improvements is presented in Table 7-8, with corresponding retrofit options presented in Table 7-9. These two tables are outlined in the same format as the process technology tables.

In addition to the low-cost/no-cost and retrofit technology opportunities, it is also important to consider opportunities associated with management practices, training and awareness:

- Management commitment to energy/water/environment. Any effective energy/water management and pollution prevention program must have the endorsement of top level management. A clear commitment by management is essential to achieving financial, image and societal benefits through pollution prevention.

- In-plant training and awareness of energy/water/environment. In dairy processing plants, operators often have discretion over the quantities of water, chemicals, and energy utilized in relation to tasks performed. Plant personnel should be trained in operational techniques that lead to cost reduction and environmental improvement.

TABLE 7-8: CHECKLIST OF IMPROVEMENT OPPORTUNITIES FOR UTILITIES AND SERVICES

PROCESS AREA	CONCERNS				OPERATING, LOW COST/NO COST	RETROFIT	REF. NO. *	COMMENTS
	Thermal	Power	Environment	Water				
Cold Water				Variable, for process, washup and utility cooling	Install water meters in different process areas to monitor consumption on an on-going basis.	Closed loop cooling water systems.	1	
					Recycle once-through cooling water to process or other uses.			
Hot Water	Variable, for washup and process.		Boiler emissions		Insulate HW tanks and lines, and hot process vessels.	Hot water heaters rather than boiler if no high temperature requirements.	2	
					Ensure appropriate water heating set points	Segregate HW system to reduce unnecessary heating.	3	
Steam	Natural gas typical		Boiler emissions		Tune boiler combustion air to achieve optimum fuel/air mixture.	Economizer on boiler	4	
					Use interruptible gas service at lower cost, if appropriate	Flue gas heat recovery, direct contact condensing heat recovery	5	
					Implement blow down heat recovery (heating washup water, boiler feed water etc.)	Heat exchange rather than direct injection	6	
					Identify and correct steam leaks	Replace boiler with hot water heaters if appropriate	2	
					Collect all possible condensate and insulate steam and condensate return lines	Cogeneration	12	
					Segregate steam system according to pressure			
					Introduce steam trap maintenance program			
					Monitor steam consumption to avoid surges			
Refrigeration		High electrical inputs	Refrigerant Leakage		Schedule compressors to reduce electrical peak demand	Segregation of refrigeration system according to temperature	7	Allows more precise switch-over.
					Insulate cold process areas to reduce summer refrigeration loads	Free cooling (refer to Table 4.7)		
					Clean evaporators and condensers	Absorption cooling	8	
					Insulate refrigerant lines			
					Reduce infiltration into cooled areas such as freezer and milk cooler			
						Thermal cold storage		
Compressed Air		Electrical drives			Analyze for air leaks and repair	Engine driven systems	9	Ultrasonic detection equipment available
						Off peak compressed air storage		
Electrical (Direct Uses)		Electrical drives				Power factor correction to reduce surcharge	10	
						Reduce unnecessary lighting, replace with higher efficiency lights.		
						High efficiency motor drives	11	
						Cogeneration	12	
		Lighting			Motion sensors			
					Programmable logic timers			

* NOTE: SEE TABLE 7-9 FOR FURTHER DESCRIPTION OF RETROFITS BY REFERENCE NUMBER

TABLE 7-9 CHECKLIST OF RETROFIT OPTIONS FOR UTILITIES AND SERVICES

REF NO.	RETROFIT	EQUIPMENT	COSTS	SAVINGS	PAYBACK	COMMENTS/ BENEFITS
1	Cooling Water	Closed Loop Cooling Systems	25-100k	15-50k	1-3 yrs	
2	Hot Water	Change Steam Boiler to HW Heaters	50-200k	10-50k	1-5 yrs	
3	Hot Water	Segregating Hot Water System	10-30k	5-15k	2-4 yrs	
4	Steam	Economizer on Boiler	10-30k	3-15k	3-5 yrs	
5	Steam	Flue gas condensing heat recovery	50-300k	20-100k	2-4 yrs	
6	Steam	Heat exchange instead of injection	10-50k	5-15k	2-3 yrs	
7	Refrigeration	Segregation of system according to temperature	20-60k	10-30k	1-2 yrs	
8	Refrigeration	Absorption Cooling	200-500k	100-300k	2-4 yrs	$400 - $600 / TR
9	Compressed Air	Engine Driven Systems	20-80k	5-20k	3-5 yrs	
10	Electrical	Power Factor Correction	20-80k	15-60k	1-2 yrs	
11	Electrical	High Efficiency Drive Motors	100-200k	30-100k	2-3 yrs	
12	Steam/Electrical	Cogeneration	400-800k	50-100k	4-8 yrs	$1,000 - $1,200 / kW, energy in proportion 1/3 electricity to 2/3 heat

A generic improvement opportunity cited is the recycle and reuse of water. If water is to be recycled within plants, appropriate management must be undertaken to address any potential health and safety concerns, especially with regard to microbial content.

Addressing concerns could involve:

- Developing appropriate policies regarding the reuse of water.
- Conducting periodic analyses of water samples to ensure satisfactory quality is maintained.
- Conducting active treatment and/or control to address and maintain quality. These could include:
  - Computer monitoring and control to ensure adequate bleed-out in recycled water systems.
  - UV treatment of water for active bacterial control.
  - Addition of appropriate chemicals.

8.0 NEW TECHNOLOGIES

A series of new technologies relevant to energy/water efficiency and pollution prevention in dairy processing plants are summarized in Table 8-1. A total of 10 relevant generic technologies have been identified. All these technologies are likely to be applicable within the next 5 to 10 years. They are either currently being researched and developed or, if commercially available, are not yet being used extensively in Ontario.

Table 8-1 is not intended to be comprehensive, and is only a starting point for site-specific evaluations. Other new technologies are also under development, which relate primarily to productivity improvement. However, any such technologies, with little or no impact on pollution prevention or resource savings, have been excluded.

The technologies presented in Table 8-1 are briefly described in the following sections:

8.1 Expert Control Systems

Expert control systems incorporate enhanced computer control to coordinate and optimize process operations. Expert control systems are now becoming commercialized, but are not yet extensively used. The costs of these systems are still relatively high, but are decreasing. Relevant applications of expert systems include:

- Control of refrigeration systems;
- Control of process operations, especially linked to water and energy use; and
- Environmental controls.

TABLE 8-1: NEW TECHNOLOGIES FOR DAIRY PRODUCTS PROCESSING

REF NO.	NAME OF TECHNOLOGY	DESCRIPTION OF TECHNOLOGY	APPLICATION	
			PROCESS	ACTIVITY
1	Expert Computer Control Systems			
		Refrigeration Control	All, especially Frozen Products	Cooling
		Manufacturing Controls (Especially linked to water use)	All	Processing
		Environmental Controls	All	Effluent
2	Non-Thermal Pasteurization Methods: Microfiltration	Initial introduction in Ontario of new technology for specialty milk. Major benefit is sustantially increased product life from typical 12-18 days to as high as 28 days. Also results in reduced thermal requirements for processing.	Primarily Fluid Milk	Pasteurization Bacterial Control
3	Non-Thermal Pasteurization Methods: High-Hydrostatic Pressure	Process commercialized in Japan for raw foods. Has significant potential for Fluid milk and milk products such as cheese. Reduced thermal requirements, but may not deactivate naturally present degenerative enzymes.	Primarily Fluid Milk and Cheese	Pasteurization Bacterial Control
4	Non-Thermal Pastourization Methods: Electrical Field Effects	Laboratory testing conducted, with method still at research and development stage.	Primarily Fluid Milk	Pasteurization Bacterial Control
5	Non-Thermal Bacterial Control: High- and Low-Intensity UV for Liquids	Potential application of High-Intensity UV to whey bacterial control. Low-Intensity applicable to water, especially where water reuse considered within plant. Developed but not applied to dairy processing.	High for Whey (Cheese), Low for Water (All)	Bacterial control.
6	Vacuum Superheated Steam Drying	High efficiency drying method, allows reuse of recovered evaporation as useful steam. Use of vacuum operation to ensure adequately low operating temperature	Dryed Products and Whey	Drying
7	Advanced High-rate Anaerobic Wastewater Treatment	Advanced treatment technologies to achieve improved performance, reduce effluent loading and reduced emissions.	All	Effluent Treatment
8	Aerobic/Anaerobic Membrane Bioreactor	Advanced compact system suitable for high strength effluents. Commercialized in other fields, but not yet applied in dairy processes	All	Effluent Treatment
9	Enzyme-based cleaners to improve CIP operations.reduce caustic and water use. Now being introduced.	Potential reduce of caustic cleaner requirements and water use for post-flushing. Now being introduced into general use.	All	CIP
10	Just-In-Time (JIT) dairy manufacturing concept	Reduction/elimination of raw and product storage, with direct movement of milk from tankers to process to packaging. Now in research and development stage by equipment manufacturers.		

8.2 Non-Thermal Pasteurization Methods

A key focus of the relevant new technologies for dairy processing is non-thermal methods for pasteurization and bacterial control. The major resource conservation benefits of such technologies are reduced energy use and extended product shelf-life. Three potential pasteurization technologies at varying stages of development are identified. These are microfiltration, high hydrostatic pressure, and electrical field effects.

The use of microfiltration, for selective exclusion of bacteria, is most advanced, being already commercialized in Ontario under the trade name "PurFiltre" process.[23] This process has already demonstrated substantial product shelf-life improvements, to upwards of 28 days. This process is considered as a new technology with regard to resource conservation because its recent introduction focused on product flavour and other attributes, rather than extended shelf-life, and the product is still largely niche oriented.

High hydrostatic pressure is a well established technology to inactivate microorganisms, and has been already commercialized in Japan for application to jams and jellies.[24] The process, however, has not been commercialized as yet in North America. This process has significant potential for application to dairy products, such as fluid milk and cheese.

Electrical field effect technologies have also demonstrated the ability to inactivate microorganisms. However, such processes are only at an early stage of development, and are not expected to be commercialized soon.

Because of food safety implications, the implementation of any new alternative pasteurization technologies can be expected to be incremental.

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[23] Refer for example to Strauss, M. Globe and Mail. July 20, 1995. B4.

[24] Pothakamury, U., G. Barbosa-Canovas, B. Swanson and R. Meyer. 1995. The Pressure Builds for Better Food Processing. Chemical Engineering Progress. Volume 91. No.3 (March). p.45-53.

8.3 Ultraviolet Non-Thermal Bacterial Control

The use of ultraviolet (UV) light for bacterial inactivation has advanced substantially over the past decade. Ultraviolet light systems are already commercialized for such processes as wastewater, potable and process water disinfection, such as in breweries. They are not currently used extensively for liquid flow streams in dairy processing plants. The effectiveness of UV systems is well established, and the application of the technology has been increasing.

UV systems are not directly relevant to milk streams. The very low transmissivity of milk, as well as the potential for off-flavour development, preclude this technology from being considered for such roles as pasteurization or bacterial control of milk rinse streams. UV is, however, highly applicable to bacterial control of whey, and water streams, such as recirculated water flows. Manufacturers of UV systems include Trojan Technologies of London, Ontario, Aquionics, Katadyn, Aquafine and Waterguard Systems.

8.4 Vacuum Superheated Steam Drying

Superheated steam drying (SSD) is a highly efficient new drying technology that allows the reuse of recovered evaporation as useful steam. In order to ensure sufficiently low temperatures to not degrade dried milk products, such systems can be operated under vacuum. Superheated steam dryers are already commercial in Europe, marketed by Niro. A vacuum superheated steam dryer (VSSD) pilot test was successfully conducted by Wardrop Engineering Inc. using milk powder in the late 1980's The technology is not likely to be justifiable for a strict retrofit operation, however, could be very economical for a situation where a new or replacement dryer is required.

8.5 Advanced High-Rate Anaerobic Wastewater Treatment

The high strength of dairy effluents is a concern when biological treatment for BOD reduction must be undertaken. The development of compact, high-rate anaerobic treatment systems, which produce low amounts of sludge are advantageous and can help to resolve this concern. A number of such systems are now already commercial, although not applied significantly in Ontario for dairy processing plants.

8.6 Aerobic/Anaerobic Membrane Bioreactor

Compact, high-rate membrane bioreactor systems, operated either aerobically or anaerobically, are another approach to dealing with the biological treatment of high strength effluents from dairy processing plants. Such systems have been commercialized already, but are not applied to dairy effluents. An example system is the Zeno-Gem manufactured by Zenon Environmental of Burlington.

8.7 Enzyme-Based Cleaners

A recent advance in cleaning chemical technology has been the introduction of enzyme-based cleaners for CIP operations. Such cleaners offer the potential to reduce caustic requirements, with reduced caustic discharges to effluent, as well as reducing final water flushing requirements. Such chemicals are now being introduced into the market.

8.8 Just-In-Time Dairy Concept

A radical potential improvement in dairy processing operations is the application of the just-in-time concept, which is a well established process in automobile assembly. This approach would reduce or eliminate raw and product milk storage, correspondingly reducing washing and milk losses. This concept is currently being developed by such equipment suppliers as Tetra-Pak and is expected to be introduced within the next decade.

9.0 OTHER HELPFUL INFORMATION FOR DAIRY PROCESSORS

Additional information, relevant to dairy processing plants, is summarized in the following sections.

9.1 Unit Performance Ratios

In assessing the performance of plants in reducing energy and water use, and effluent discharges, the use of unit performance ratios is highly useful. A series of these ratios is presented in the following section. The ratios are structured in a manner so as to provide valid assessment, but at the same time to maintain confidentiality. This would allow the collection of data from a broad range of plants for statistical analysis purposes.

All the unit performance ratios are presented per Litre of raw milk or equivalent. This is done to allow valid comparisons with available literature data, and between dairy processing operations. In the case of industrial milk processing operations, comparison on the basis of kilogram of milk solids instead may be more appropriate. To compensate for the use of different performance ratio units (e.g., Litres of raw milk or kg of milk solids), information on conversion is included in Table 9.2.

9.1.1 Unit Electrical Energy Use

This unit performance ratio would be calculated using the following formula, and reported in units of kWh per Litre of Raw Milk:

$$\textit{Unit Electrical Energy Use} = \frac{\textit{Total kWh Electricity Used Over } 12 \textit{ Month Period}}{\textit{Total Litres Raw Milk Received Over Same } 12 \textit{ Months}}$$

The range of values expected for this ratio is approximately 0.12 to 0.32 kWh per Litre.

9.1.2 Unit Natural Gas Energy Use

This unit performance ratio would be calculated using the following formula, and reported in units of MJ per Litre of Raw Milk:

$$\text{Unit NG Energy Use} = \frac{\text{Total } m^3 \text{ Natural Gas Used Over 12 Month Period} \times 45\ MJ/m^3}{\text{Total Litres Raw Milk Received Over Same 12 Months}}$$

The range of values expected for this ratio is approximately 0.56 to 5.24 MJ per Litre.

9.1.3 Unit Water Use

This unit performance ratio would be calculated using the following formula, and reported in units of Litres of water per Litre of Raw Milk:

$$\text{Unit Water Use} = \frac{\text{Total } m^3 \text{ Water Used Over 12 Month Period} \times 1{,}000\ L/m^3}{\text{Total Litres Raw Milk Received Over Same 12 Months}}$$

This value is expected to be in the range of 1 to 3 Litre per Litre for fluid milk plants, and upwards of 5 Litre per Litre for industrial milk plants. Water employed in products or reconstitution is not to be included in total water use.

9.1.4 Ratio of BOD Equivalent Loss to Actual Milk Loss

This unit performance ratio is most important for fluid milk plants discharging to municipal sanitary systems, and would be calculated as a dimensionless ratio as follows:

$$\text{BOD to Actual Loss} = \frac{\text{Estimated 12 Month Equivalent Litres Loss Derived from Plant BOD}}{\text{Actual Estimated Litres Milk Lost for Same 12 Months}}$$

Where:

$$BOD\ Derived\ Loss = \frac{AVG\ mg/L\ BOD^{*} \times 1{,}000\ L/m^3 \times m^3/yr\ Effluent \times 10\ L\ Milk/kg\ BOD}{10^6\ mg/kg}$$

* Note: Average 12 month BOD value of effluent prior to any treatment.

A ratio value close to 1.0 for a plant indicates that a relative BOD balance exists, while a value significantly larger than 1.0 (e.g., in the range of as high as 2.0 to 3.0) indicates a potential BOD imbalance.

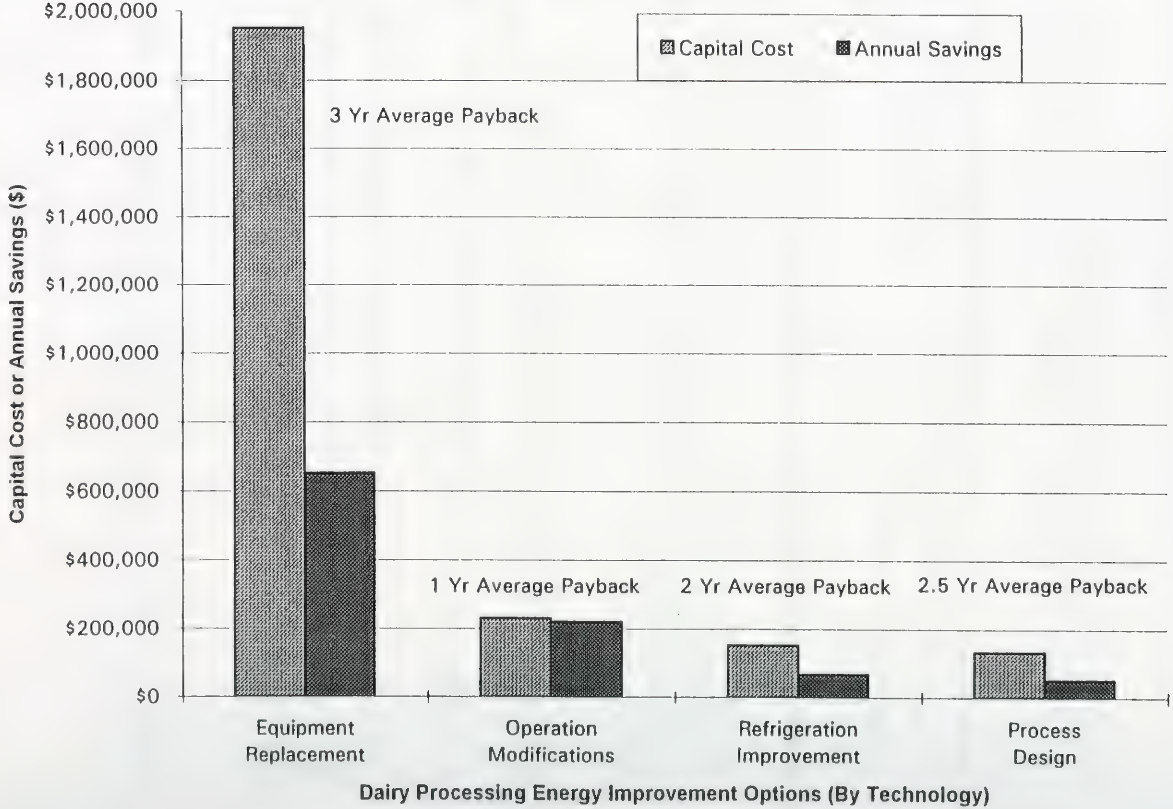
9.2 Industry Conservation Branch Data on Improvements

The Industry Conservation Branch of the Ministry of Environment and Energy provides assistance to Ontario industries in a variety of forms, including the following two programs targeted at assisting individual plants:

- Industrial Energy Services Program (IESP); and
- Green Industry Analyses and Retrofits (GIAR) program.

Through the operation of these specific programs, significant relevant information has been developed in support of the dairy processing sector, as summarized in the following sections.

FIGURE 9.1: Estimated Capital Costs and Annual Savings Associated with Energy Improvements at Ontario Dairy Processing Plants



9.2.1 Audit Data (IESP) for Selected Ontario Dairy Energy Improvements

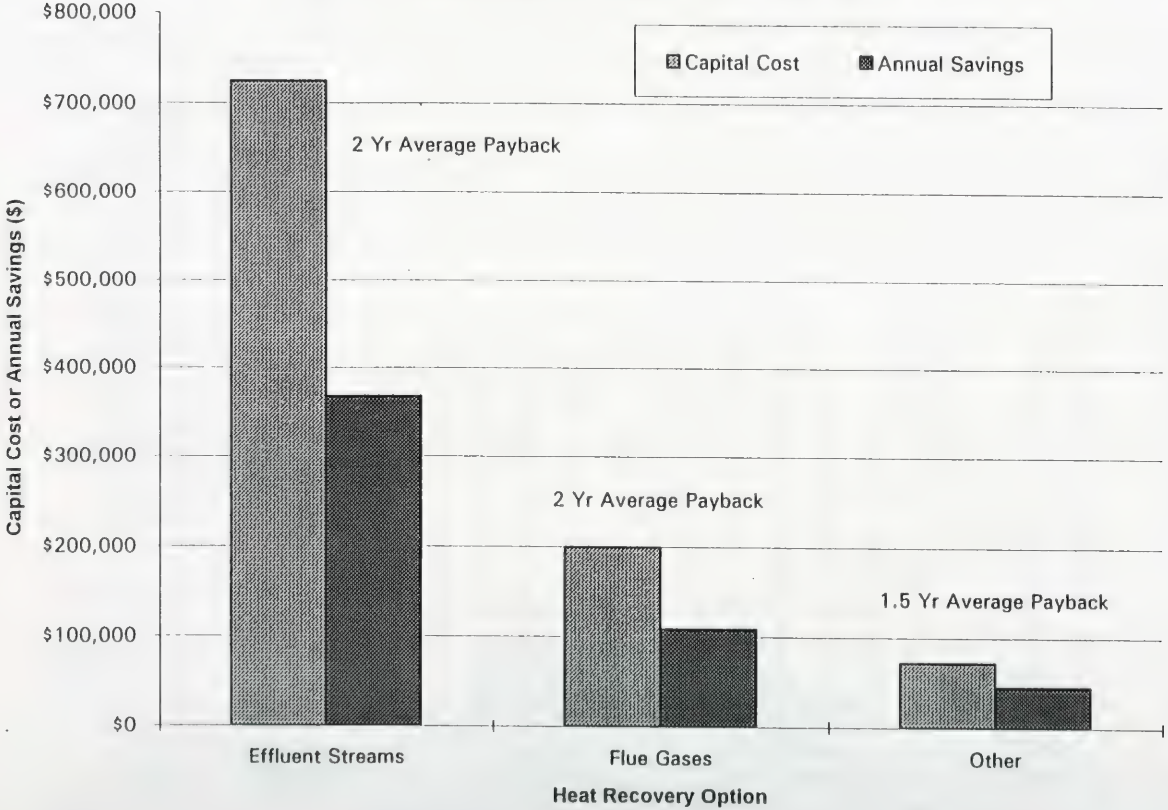
Under the IESP, Energy Analyses have been conducted at a total of 17 different dairy processing plants in Ontario since 1987. These plants are listed as follows:

- Brookside Dairy Division, Kingston.
- Maple Lane Dairy Division, Kitchener.
- Neilson Dairy, Ottawa.
- Palm Dairies Limited, Thunder Bay.
- The Becker Milk Company, Scarborough.
- Ault Foods Limited, Winchester.
- Bright Cheese House, Woodstock.
- Champlain Industries Limited, Tara.
- Champlain Industries Limited, Cornwall.
- Gay Lea Foods Co-operative Limited, Guelph.
- Kraft General Foods Canada Ltd., Ingleside.
- McCain Foods, Harrowsmith.
- McCain Refrigerated Foods, Oakville.
- Saputo Cheese Division, Cookstown.
- Tavistock Cheese Division, Tavistock.
- The Borden Company Ltd., Ingersoll.
- Thornloe Cheese Factory, Thornloe.

Based on the results of these IESP audits, information on energy improvement projects by technology type are summarized as follows:

- Figure 9.1 presents aggregated estimates of capital expenditures and annual energy savings for four categories of process improvements: (1) equipment replacements, (2) operation modifications, (3) refrigeration improvements, and (4) process redesigns.

FIGURE 9.2: Estimated Capital Costs and Annual Savings Associated with Improvements in Ontario Dairy Processing Plant Heat Recovery



- Figure 9.2 also presents aggregated estimates of capital expenditures and annual energy savings derived from IESP audits for three categories of energy recovery: (1) effluent streams, (2) flue gases, and (3) others.

9.2.2 Green Industry Analysis Case Studies

The Green Industry Analyses and Retrofits program (GIAR) was initiated in August, 1994 to encourage the comprehensive analysis of specific industrial plants in order to identify opportunities for reduction of energy and water use, and other environmental improvements, such as reducing wastes. As part of this program, publicly available case studies are prepared for each Green Industry Analysis undertaken.

The first Green Industry Analysis under the new program was completed at a dairy processing plant, The Becker Milk Company Ltd., in Scarborough. This plant incorporates both fluid milk and ice cream production. A public Case Study document describing this study was prepared and is included in Appendix D.

A second Green Industry Analysis has been conducted at another dairy processing plant, in this case the Ault Food's facility at Winchester. This industrial milk plant primarily involves cheese production, as well as whey processing and drying. A public Case Study document describing this study will be available in the Fall of 1995.

9.3 Advanced Analysis Methodologies

A comprehensive approach to analyzing pollution prevention, and water and energy use reduction is essential in the case of complex processes. An example approach, identified in a recent food industry sector technology study, sponsored by Natural Resources Canada, is the use of Energy Process Integration (EPI) or *Pinch* analysis for determining the most cost effective energy reduction opportunities. A series of references describing this technique and example assessments are summarized in Appendix E.

9.4 References Materials on Energy and Environmental Improvements

A series of additional reference materials relevant to dairy processing plants are described in the following sections.

9.4.1 Natural Resources Canada

Natural Resources Canada. 1994. CEMET Resource Catalogue: List and description of available energy efficiency products and services.

Natural Resources Canada. A Manager's Guide to Creating Awareness of Energy Efficiency. Efficiency and Alternative Energy Program.

Natural Resources Canada. 1994. Technical Information. Efficiency and Alternative Energy Program.

Canadian Industry Program for Energy Conservation. CIPEC Energy Efficiency Planning and Management Guide.

Maunder Britnell Inc. 1993. Energy Efficiency R&D Opportunities in the Food and Beverage Sector Phase 1 - Scoping Study. Report for Energy Efficiency Division, Efficiency and Alternative Energy Technology Branch, Natural Resources Canada. CANMET Contract No. EA9710-8-1. October, 1993.

9.4.2 Ontario Hydro and Other Hydro Utilities

A series of Product Knowledge Reference Guides are available from Ontario Hydro, as follows:

- Power Quality
- Adjustable Speed Drives
- Motors
- Membrane Technology
- Fans
- Pumps
- Refrigeration

Additional technology reports and case studies are available from Ontario Hydro.

Useful information has also been compiled by other electrical utilities, including the following document: B.C. Hydro. 1992. Guides to Energy Management: Efficiency initiatives produce savings and win certificate of merit for Dairyland Foods.

9.4.3 International Energy Agency Case Studies

A summary of case studies relevant to dairy processing plants prepared by the Centre for the Analysis and Dissemination of Demonstrated Energy Technologies (CADDET) is provided in Table 9-1.

9.4.4 Environmental Discharges from Dairy Processing Plants

Carawan, R., M. Parkin and W. Harper. 1984. Waste Management Control Handbook for Dairy Food Plants. U.S. Environmental Protection Agency, Office of Research and Development. EPA-600/2-84-043.

TABLE: 9-1: SUMMARY OF CADDET CASE STUDIES RELEVANT TO DAIRY PROCESSING

REFERENCE	COUNTRY	COMPANY	TITLE
NL 92.008/21.X00	Netherlands	Coberco Dairy	Continuous Production of Small Volumes in the Dairy Industry
2A.C05.NO.90.001	Norway	Namdalsmeieriet	Combined Heat Recovery and Purification Plant at a Dairy
JP 90.142./2A.H03	Japan	Meiji Milk Products Co.	Quadruple-effect Evaporator uses Mechanical Vapour Recompression
NL.92.505/2a.f04	Netherlands	Campina Melkunie	Energy Efficient Hardening Tunnel for Ice Cream
Dec-92	United States	Steuben Foods	"Pinch" Technology Applied to a Dairy Processing Plant
Dec-92	Netherlands	Netherlands Institute for Dairy Research	Cleaning of Heat Exchangers and Evaporators after Processing Milk or Whey
Dec-92	Australia	New South Wales Dairy Corporation	Ice Storage in Dairy Farms in New South Wales, Australia
AU-90-021	Australia	Ibis Milk Products Ltd.	Recovery of Contaminated Condensate from Milk
CH-89-001	Switzerland	Vallait S.A.	Recovering Waste Heat of the Refrigeration Plant in a Dairy
CH-89-007	Switzerland	Toni Dairy	Heat Recovery from Boiler Feedwater Degassing
CH-89-008	Switzerland	Toni Dairy	Heat Recovery from Flushing Water
CH-89-026	Switzerland		Heating of Cleaning Water by a Heat Pump in a Dairy
CH-89-009	Switzerland	PAG	Improved Control of Air Compressors and Heat Reovery Reduce Cost of Compressed Air
NL-87-064	Netherlands		Use of Condensate in the Dairy Industry
NL-92-011	Netherlands		Construction of a Cooling System with Heat Recovery in a Tofu Factory
NL-92-509	Netherlands	Coberco	Continuous Manufacture of Custard with Heat Recovery
NL-92-519	Netherlands	VHL	Application of New Generation of Homogenizers in the Dairy Industry
NL-93-531	Netherlands	Borculo Whey	Renewal Control of Lactose Dryers
NL-93-532	Netherlands	Borculo Whey	High Concentrating During Whey Processing
NL-93-534	Netherlands	Coberco	Fat Injection at an Evaporation Process
NL-94-533	Netherlands	Humelco	New Spray Drying Process
NO-88-003	Norway	L/L Sunmre Meieri	Reducing Whey using Mechanical Vapour Recompression
UK-87-016	United Kingdom	Magness and Usher	Insulated Trucks for Wholesale Milk Delivery
UK-87-034	United Kingdom	Unigate Dairy	Electrically Driven Heat Pumps for Waste Heat for Waste Heat Recovery
UK-87-174	United Kingdom		Mechanical Vapour Recompression Heat Pump in the Evaporation of Skim Milk Concentrate
UK-87-401	United Kingdom	Unigate	Gas-Fired Heaters Replace Steam at Dairy for inplace Tank Cleaning and Pasteurizing
UK-94-522	United Kingdom	Associated Dairies- MD Foods	Energy Monitoring and Target Setting at a Dairy
UK-94-526	United Kingdom	Romford Brewery	Variable Speed Drives on Secondary Refrigeration Pumps
US-89-101	United States		Energy Conservation in Food-Processing Plants, by Heat Recovery and Efficient Boiler Operation
US-89-103	United States		Energy Audit Demonstrates the Potential for Energy Conservation in an Operating Dairy Plant: Creamer

Harper. W., R. Delaney. I. Igbeka. M. Parkin and W. Schiffermiller. 1985. Strategies for Water and Waste Reduction in Dairy Food Plants. U.S. Environmental Protection Agency. EPA/600/2-85/076.

Herzka. A. and R. G. Booth. ed. 1981. Food Industry Wastes: Disposal and Recovery. Applied Science Publishers. ISBN 0-85334-957-6.

Niranjan. K., M. Okos, and M. Rankowitz. ed. 1994. Environmentally Responsible Food Processing. American Institute of Chemical Engineering. AIChE Symposium Series. Volume 90. No. 300. ISBN 0-8169-0651-3.

9.4.5 Pollution Prevention Guidance Documents

Ontario Ministry of Environment and Energy. 1993. Pollution Prevention Planning: Guidance Document and Workbook. PIBS 2586E. ISBN 0-7778-1441-2.

Canadian Standards Associations. 1994. Guideline for Pollution Prevention. Z754-94.

Canadian Standards Associations. 1994. Environmentally Responsible Procurement. Z766-94.

Water and Wastewater Management in a Dairy Processing Plant. Series: Bank or Drain. Pollution Prevention Pays in Food Processing. North Carolina Agricultural Extension Service. CD-28.

Cut Waste to Reduce Surcharges for Your Dairy. Series: Bank or Drain. Pollution Prevention Pays in Food Processing. North Carolina Agricultural Extension Service. CD-26.

Liquid Assets for Your Dairy Plant. Series: Bank or Drain. Pollution Prevention Pays in Food Processing. North Carolina Agricultural Extension Service. CD-21.

TABLE 9-2A PRODUCTION VOLUMES

	YEAR			
	1990	1991	1992	1993
Butterfat Production - tonnes of butterfat				
Sold For Fluid	108,180	108,786	110,752	107,727
Sold for Industrial				
As Milk	164,284	161,197	149,578	148,132
As Cream	4,860	4,610	4,298	2,824
Total Shipments	277,324	274,593	264,628	258,683
Fluid Volumes - kiloLitres (cubic meters)				
Sold For Fluid	2,711,948	2,716,201	2,728,721	2,710,234
Sold for Industrial				
As Milk	4,471,024	4,395,264	4,025,159	3,992,810
As Cream	135,033	128,832	119,984	78,030
Total Shipments	7,318,005	7,240,297	6,873,864	6,781,074

TABLE 9-2B CONVERSION OF MILK SOLIDS AND MILK VOLUME

	YEAR				AVERAGE VALUE
	1990	1991	1992	1993	
Ratio of kg Butterfat to Litres of Milk Volume					
Sold For Fluid	0.0399	0.0401	0.0406	0.0397	0.0401
Sold for Industrial					
As Milk	0.0367	0.0367	0.0372	0.0371	0.0369
As Cream	0.0360	0.0358	0.0358	0.0362	0.0359
Total Shipments	0.0379	0.0379	0.0385	0.0381	0.0381
Ratio of Litres of Milk Volume to kg of Butterfat					
Sold For Fluid	25.07	24.97	24.64	25.16	24.96
Sold for Industrial					
As Milk	27.22	27.27	26.91	26.95	27.09
As Cream	27.78	27.95	27.92	27.63	27.82
Total Shipments	26.39	26.37	25.98	26.21	26.24

Data from: StatsCan Publication - The Dairy Review, Cat No. 23-002
and Cat No. 23-001

Dairy CEO's: Do You Have a $500 Million Opportunity?. Series: Bank or Drain, Pollution Prevention Pays in Food Processing. North Carolina Agricultural Extension Service. CD-29.

9.4.6 Food Packaging

Brown, W. 1992. Plastics in Food Packaging. Marcel Dekker. ISBN 0-8247-8685-8.

Robertson, G. 1993. Food Packaging: Principles and Practice. Marcel Dekker. ISBN 0-8247-8749-8.

9.5 Liquid Milk - Milk Solids Conversions

Based on production quantities presented in Table 9-2A, conversions between liquid milk and milk solids are presented in Table 9-2B.

GLOSSARY OF ACRONYMS

AAFC	Agriculture and Agri-Food Canada
BOD	Biological Oxygen Demand
CADDET	Centre for the Analysis and Dissemination of Demonstrated Energy Technologies
CCME	Canadian Council of Ministers of the Environment
CIP	Clean-in-Place
CIPEC	Canadian Industry Program for Energy Conservation
COP	Clean-Out-of-Place
DAF	Dissolved Air Flotation
DPRIS	Dairy Plant Regulated Inspection System
EPA	U.S. Environmental Protection Agency
EPI	Energy Process Integration
GATT	General Agreement on Tariffs & Trade
GIAR	Green Industry Analysis & Retrofits
HACCP	Hazard Analysis and Critical Control Points
HC	Health Canada
HTST	High Temperature Short Time Pasteurizer Unit
IESP	Industrial Energy Services Program
JIT	Just-in-Time Manufacturing Concept
MOEE	Ontario Ministry of Environment and Energy
MOH	Ontario Ministry of Health
MOU	Memorandum of Understanding
MSQ	Market Share Quota

NAPP	National Packaging Protocol
NAFTA	North American Free Trade Agreement
NPRI	National Pollutant Release Inventory
OMAFRA	Ontario Ministry of Agriculture, Food and Rural Affairs
OMMB	Ontario Milk Marketing Board
PE	Polyethylene
PP	Polypropylene
PST	Private Sewage Treatment
SIC	Standard Industry Classification
SPI	Society of Plastics Institute
SSD	Superheated Stream Drying
TKN	Total Kjeldahl Nitrogen
TP	Total Phosphorus
TRI	Toxic Release Inventory
TSS	Total Suspended Solids
VSSD	Vacuum Superheated Steam Dryer

APPENDIX A

APPENDIX A: LIST OF DAIRY PROCESSING PLANTS IN ONTARIO

Fluid Milk

- Archers Dairy -	Kirkland Lake
- Astro Dairy Products -	Etobicoke
- Augustine's Dairy -	Port Colborne
- Ault Foods Ltd. -	Don Mills
	Orleans
	Copper Cliff
	London
- Beatrice Foods -	Thunder Bay
	Brampton
	Timmins
	Kitchener
	Sudbury
	Kingston
- Brant Dairy Co. Ltd. - (Natrel)	Brantford
- Brum's Dairy -	Pembroke
- Christie's Dairy Ltd. -	Beamsville
- Cochrane's Dairy Ltd. -	Russell
- Community Dairy of Kapuskasing -	Kapuskasing
- Becker Milk -	Cornwall
	Scarborough
- Fieldfresh Farms Inc. -	Oakville
- Dairyworld Foods -	Brampton
- Hewitt's Dairy Ltd. -	Hagersville
- Kawartha Dairy Ltd. -	Bobcaygeon
- Lakeside Jersey Dairy -	Leamington
- Laurentian View Dairy -	Deep River
- Longlife of Canada Ltd. -	Weston
- Steen's Dairy Ltd. -	Erin
- Sunrise Dairy -	Wingham
- Reid's Dairy Co. Ltd. -	Belleville
- Farquhar Dairy -	Espanola
- Vacationland Dairy Ltd.-	Kenora
- Neilson Dairy -	Halton Hills
	Ottawa

Cheese (specialty/cheddar)

- A.M. Jensen Ltd. -	Simcoe
- Armstrong Foods -	Ingersoll
- Astro Dairy Products -	Etobicoke
- Atwood Cheese Co. Ltd. -	Atwood
- Ault Foods -	Balderson
	Winchester
	Thornloe
- Beatrice Foods Inc. -	St. George
- Black Diamond Cheese -	Belleville
- Bright Cheese & Butter -	Bright
- Bright Cheese House -	Woodstock
- Eldorado Cheese Ltd. -	Eldorado
- Empire Cheese & Butter-	Campbellford
- Evanoff Cheese Factory -	Caledon
- Ferrante Cheese -	Woodbridge
- Forfar Dairy Ltd. -	Portland
- Gay Lea Foods Coop -	Baden
- Gos and Gris Cheese Ltd. -	Hannon
- Grande Cheese Co. Ltd. -	Weston
- Henry Foods Inc. -	Plainfield
- Holly Foods Corporation -	Smiths Falls
- International Cheese Co. -	Toronto
- Ivanhoe Cheese Inc. -	Madoc
- J.M. Schneider Inc. -	Winchester
- Kawartha Goat Cheese -	Indian River
- Kraft Canada Inc. -	Wolfe Island
	Ingleside
	Williamstown
- Local Dairy Products Ltd. -	Kitchener
- Mannina Cheese Co. Ltd. -	Windsor
- Mariposa Dairy -	Oakwood
- McCain Refrigerated Foods Inc. -	Oakville
	Harrowsmith
	Tavistock
- Millbank Cheese & Butter - (J.M. Schneider Inc.)	Millbank
- Morra Cheese -	Unionville
- National Cheese Co. Ltd. -	Concord
- Nova Cheese -	Ariss
- Oak Grove Cheese Factory Ltd. -	New Hamburg
- Skotidakis -	St. Eugene
- Pine River Cheese & Butter Coop-	Ripley
- Pinnau Dairy Products Ltd. -	Cambridge
- Portugese Cheese Co. Ltd. -	Toronto
- Riverside Cheese & Butter Inc. -	Trenton
- Roman Cheese Products Ltd. -	Niagara Falls
- Salerno Dairy Products Ltd. -	Hamilton
- Saputo Cheese Ltd. -	Cookstown
- Silani Sweet Cheese Ltd. -	Schomberg
- The Black River Cheese Co. Ltd. -	Milford
- St. Albert Co-op Cheese -	St. Albert
- Uniondale Cheese Factory Inc. -	Lakeside
- Westhill Dairy Inc. -	Downsview
- Wilton Cheese Factory -	Odessa

Ice Cream and Frozen

- Augustine's Dairy -	Port Colborne
- Ault Foods Ltd. -	London
- Becker Milk Co. Ltd. -	Scarborough
- Good Humor -	Simcoe
- Central Smith Dairy -	Peterborough
- Centreside Dairy 80 -	Renfrew
- Christie's Dairy Ltd. -	Grimsby
- David Chapman's Ice Cream Ltd. -	Markdale
- Farquhar Dairies Ltd. -	Mindemoya
- Gary Hart Productions Inc. -	Toronto
- Gelatissimo Ltd. -	Woodbridge

- Hewitt's Dairy - Hagersville
- Kawartha Dairy Ltd. - Bobcaygeon
- Laurentian View Dairy - Deep River
- Maypole Dairy Products- Toronto
- Metropolitan Ice Cream - Toronto
- Peterson Ice Cream - Almonte
- Sicilian Ice Cream - Toronto
- Baskin Robbins - Peterborough
- St. Clair Ice Cream Ltd. - Toronto
- Steen's Dairy Ltd. - Erin
- Reid's Dairy Co. Ltd. - Belleville

Butter

- Ault Foods Ltd. - Mitchell
  Winchester
  New Dundee
- Farquhar Dairies Ltd. - Mindemoya
- Gay Lea Foods Coop. - Guelph
  Teeswater
- McCain Refrigerated Foods Inc. - Harrowsmith
- Millbank Cheese & Butter - Millbank
  (J.M. Schneider)
- Riverside Cheese & Butter Inc. - Trenton
- Alliston Creamery Ltd. - Alliston
- Stirling Creamery - Stirling

Cultured

- Astro Dairy Products - Etobicoke
- Beatrice Foods Inc. - St. George
- Gay Lea Foods Coop. - Weston
- Hewitt's Dairy Ltd. - Hagersville
- Local Dairy Products - Kitchener
- M.C. Dairy Co. Ltd. - Toronto
- Skotidakis - St. Eugene
- Pinnau Dairy Products - Cambridge
- Reid's Dairy Co. Ltd. - Belleville
- Westhill Dairy Inc. - Downsview
- Neilson Dairy - Halton Hills
- Woodstock Milk Specialties Ltd. - Woodstock

Evaporated/Dried Products

- Ault Foods Ltd. - Mitchell
  Winchester
  New Dundee
- Beatrice Foods Inc. - St. George
- Champlain Industries - Tara
- Gay Lea Foods Coop - Guelph
  Teeswater
- Glen Arrow Products - Woodstock
- McCain Refrigerated Foods Inc. - Oakville
- Nestle Canada Inc. - Alexandria

APPENDIX B

APPENDIX B: ADDITIONAL ENERGY DATA FOR DAIRY PROCESSING PLANTS IN CANADA

TABLE B1: ENERGY COSTS FOR DAIRY PROCESSING PLANTS IN CANADA - 1992

Parameter	**Fluid Milk** SIC 1041	**Industrial Dairy Products** SIC 1049
Number of Plants	140	168
Energy Cost (including Diesel fuel costs)	$49.95 million per year	$50.14 million per year
Mean Energy Cost per Plant (including Diesel fuel costs)	$357,000 per year	$298,000 per year
Mean Energy Cost per Plant (not including Diesel fuel costs)	$296,00 per year	$286,000 per year

TABLE B2: ENERGY COSTS FOR "LARGER"DAIRY PROCESSING PLANTS IN CANADA - 1992

(these numbers represent consumption for plants accounting for at least 80% of Canadian production)

Parameter	**Fluid Milk** SIC 1041	**Industrial Dairy Products** SIC 1049
Number of Plants	107	103
Energy Cost (including Diesel fuel costs)	$45.87 million per year	$45.57 million per year
Mean Energy Cost per Plant (including Diesel fuel costs)	$429,000 per year	$442,000 per year

TABLE B3: UNIT ENERGY COSTS FOR DAIRY PROCESSING PLANTS IN CANADA - 1992

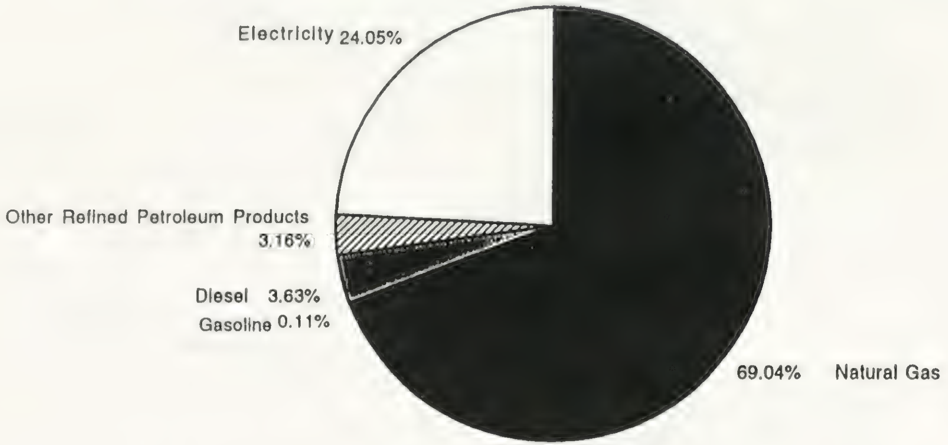
Parameter	**Fluid Milk** SIC 1041	**Industrial Dairy Products** SIC 1049
Total Raw Milk Received	2.76 Million kilolitres per year	4.15 Million kilolitres per year
Unit Energy Cost		
- with diesel	1.81 ¢ per L raw milk	1.21 ¢ per L raw milk
- without diesel	1.50 ¢ per L raw milk	1.16 ¢ per L raw milk
Electricity Intensity	0.185 kWh per L raw milk	0.104 kWh per L raw milk
Natural Gas Intensity	1.13 MJ per L raw milk	1.17 MJ per L raw milk
Proportion of Total Energy Costs:		
Electricity	50.8%	46.1%
Natural Gas	12.9%	28.5%

Source

Energy Use data from special edit of Statistics Canada's Annual Survey of Manufacturers - 1992

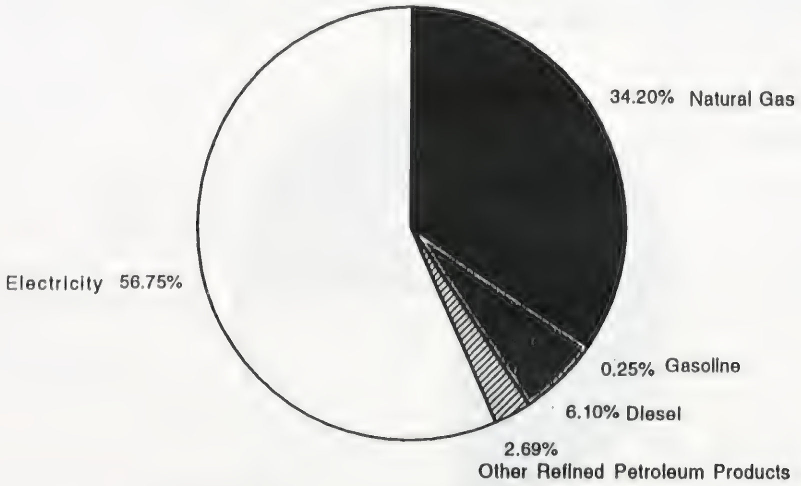
Milk Input data from Statistics Canada - Matrix 5850

Energy Consumption by Industrial Milk Processing Plants in Ontario - 1992



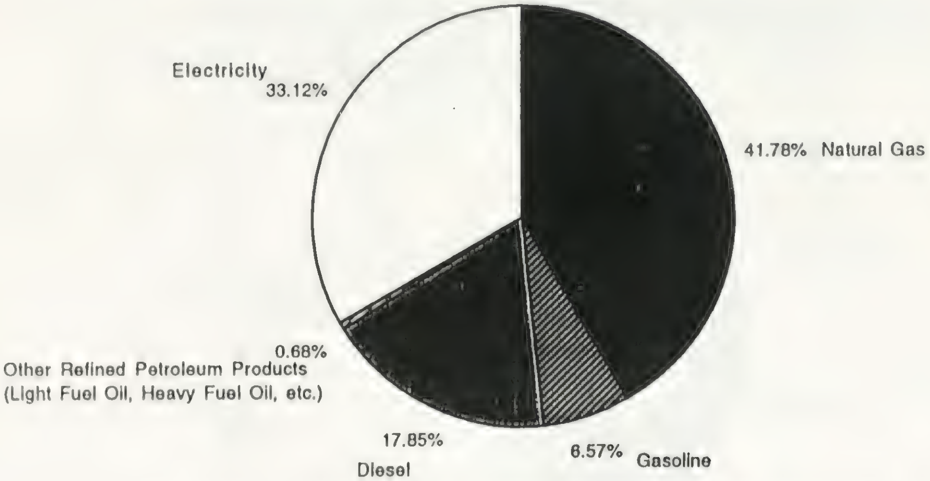
Total Energy Consumed by Industrial Milk Plants = 2,712.2 Terajoules

Energy Costs for Industrial Milk Processing Plants in Ontario - 1992



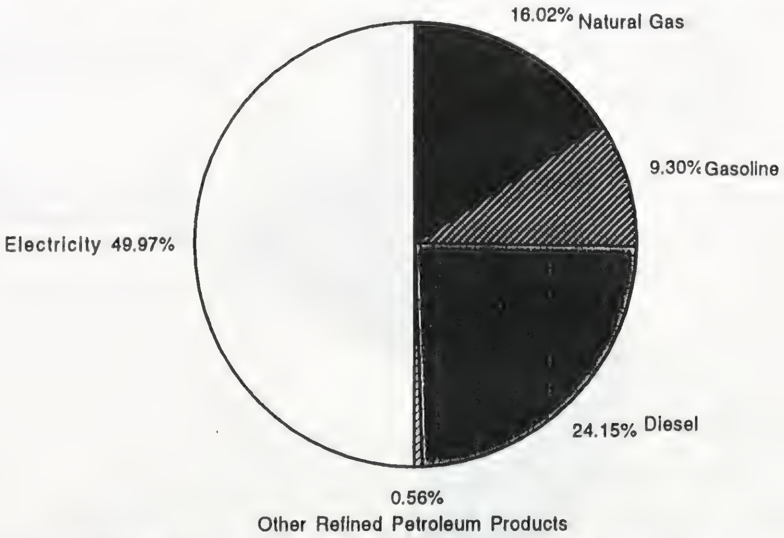
Total Energy Costs by Industrial Milk Plants = $18.067 million

Energy Consumption by Fluid Milk Plants in Ontario - 1992



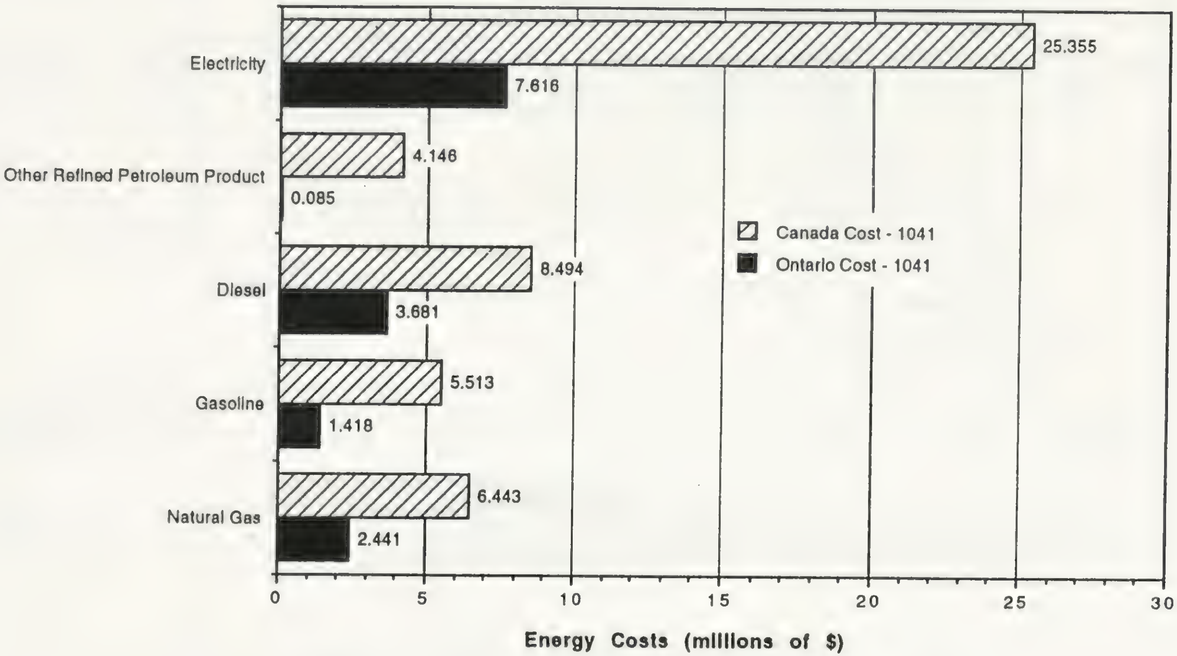
Total Energy Consumed by Fluid Milk Plants = 1,736.5 Terajoules

Energy Costs for Fluid Milk Plants in Ontario - 1992

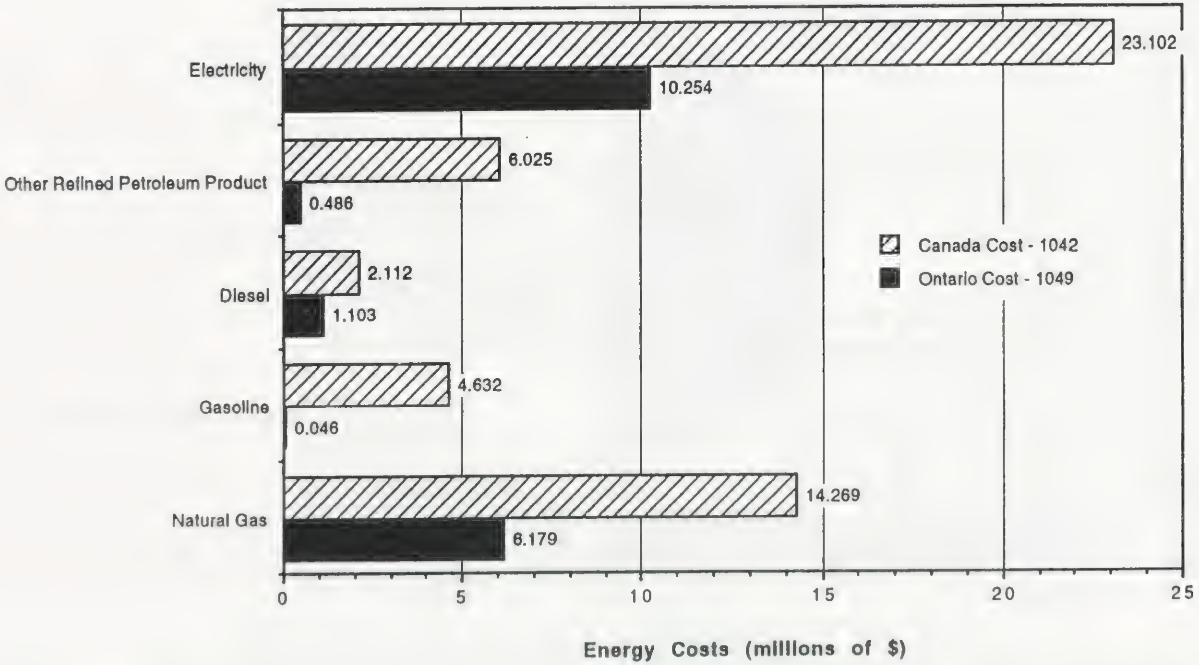


Toatl Energy Costs by Fluid Milk Plants = $15.241 million

Comparison of Energy Costs between Ontario and Canada for SIC 1041 - Fluid Milk



Comparison of Energy Costs between Ontario and Canada for SIC 1049 - Industrial Milk Products



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CONSUMPTION OF PURCHASED FUEL & ELECTRICITY - DAIRY INDUSTRIES - CANADA - 1992

Source - CPFE Data derived from special edit of Statistics Canada's Annual Survey of Manufacturers

SIC	NG		Gasoline		Diesel		LFO		HFO		LPG		Elect		Total		Other Fuels	
1041 (Physical amount)	62,700.0	k-cubic metres	10,150.0	kilolitres	18,545.0	kilolitres	6,497.0	kilolitres	3,541.0	kilolitres	4,835.0	kilolitres	470.5	GW.h				
1041 (Dollar Value)	$5.923	million	$5.088	million	$7.808	million	$2.314	million	$0.409	million	$1.088	million	$23.308	million	$45.918	million	$4.033	million
1041 (Energy - Terajoules)	2,380.7	TJ	351.8	TJ	680.2	TJ	238.3	TJ	147.8	TJ	192.5	TJ	1,693.8	TJ	5,685.2	TJ		
% of Total 1041 Energy Use	41.88%		6.19%		11.97%		4.19%		2.60%		3.39%		29.79%		100.00%			
% of Total 1041 Energy Costs	12.90%		11.04%		17.00%		5.04%		0.89%		2.37%		50.76%		100.00%			
1049 (Physical amount)	100,600.0	k-cubic metres	8,006.0	kilolitres	4,546.0	kilolitres	5,285.0	kilolitres	10,302.0	kilolitres	11,827.0	kilolitres	396.6	GW.h				
1049 (Dollar Value)	$13.088	million	$4.249	million	$1.937	million	$1.943	million	$1.392	million	$2.191	million	$21.190	million	$45.990	million	$4.149	million
1049 (Energy - Terajoules)	3,819.8	TJ	277.5	TJ	166.7	TJ	193.9	TJ	429.9	TJ	471.0	TJ	1,427.8	TJ	6,786.5	TJ		
% of Total 1049 Energy Use	56.29%		4.09%		2.46%		2.86%		6.33%		6.94%		21.04%		100.00%			
% of Total 1049 Energy Costs	28.46%		9.24%		4.21%		4.22%		3.03%		4.76%		46.08%		100.00%			
NG = Natural Gas LFO = Light Fuel Oil HFO = Heavy Fuel Oil LPG = Liquified Petroleum Gases																		
Conversion factors	0.03797		0.03466		0.03668		0.03668		0.04173		0.03982		3.6					

CONSUMPTION OF PURCHASED FUEL & ELECTRICITY - DAIRY INDUSTRIES - CANADA - 1992

(Values adjusted by distributing "other fuel" to each fuel type according to initial market share)

SIC	NG		Gasoline		Diesel		LFO		HFO		LPG		Elect		Total	
1041 (Physical amount)	68,207.0	k-cubic metres	11,041.5	kilolitres	20,173.8	kilolitres	7,067.6	kilolitres	3,852.0	kilolitres	5,259.7	kilolitres	511.8	GW.h		
1041 (Dollar Value)	$6.443	million	$5.513	million	$8.494	million	$2.517	million	$0.445	million	$1.184	million	$25.355	million	$49.951	million
1041 (Energy - Terajoules)	2,589.8	TJ	382.7	TJ	740.0	TJ	259.2	TJ	160.7	TJ	209.4	TJ	1,842.6	TJ	6,184.5	TJ
% of Total 1041 Energy Use	41.88%		6.19%		11.97%		4.19%		2.60%		3.39%		29.79%		100.00%	
1049 (Physical amount)	109,675.7	k-cubic metres	8,728.3	kilolitres	4,956.1	kilolitres	5,761.8	kilolitres	11,231.4	kilolitres	12,894.0	kilolitres	432.4	GW.h		
1049 (Dollar Value)	$14.269	million	$4.632	million	$2.112	million	$2.118	million	$1.518	million	$2.389	million	$23.102	million	$50.139	million
1049 (Energy - Terajoules)	4,164.4	TJ	302.5	TJ	181.8	TJ	211.3	TJ	468.7	TJ	513.4	TJ	1,556.6	TJ	7,398.7	TJ
% of Total 1049 Energy Use	56.29%		4.09%		2.46%		2.86%		6.33%		6.94%		21.04%		100.00%	

July 14, 1995

CONSUMPTION OF PURCHASED FUEL & ELECTRICITY - DAIRY INDUSTRIES - ONTARIO - 1992

Source - CPFE Data derived from special edit of Statistics Canada's Annual Survey of Manufacturers

SIC	NG		Gasoline		Diesel		LFO		HFO		LPG		Elect		Total		Other Fuels	
1041 (Physical amount)	15,500.0	k-cubic metres	2,669.0	kilolitres	6,852.0	kilolitres	6.0	kilolitres	72.0	kilolitres	158.0	kilolitres	129.6	GW.h				
1041 (Dollar Value)	$1.980	million	$1.150	million	$2.986	million	$0.002	million	$0.009	million	$0.058	million	$6.177	million	$12.362	million	$2.879	million
1041 (Energy - Terajoules)	588.5	TJ	92.5	TJ	251.3	TJ	0.2	TJ	3.0	TJ	6.3	TJ	466.6	TJ	1,408.5	TJ		
% of Total 1041 Energy Use	41.78%		6.57%		17.84%		0.02%		0.21%		0.45%		33.12%		100.00%			
% of Total 1041 Energy Costs	16.02%		9.30%		24.15%		0.02%		0.07%		0.47%		49.97%		100.00%			
1049 (Physical amount)	39,800.0	k-cubic metres	73.0	kilolitres	2,189.0	kilolitres	490.0	kilolitres	658	kilolitres	616	kilolitres	147.8	GW.h				
1049 (Dollar Value)	$5.003	million	$0.037	million	$0.893	million	$0.181	million	$0.102	million	$0.110	million	$8.303	million	$14.629	million	$3.438	million
1049 (Energy - Terajoules)	1,511.2	TJ	2.5	TJ	80.3	TJ	18.0	TJ	27.5	TJ	24.5	TJ	532.1	TJ	2,196.1	TJ		
% of Total 1049 Energy Use	68.81%		0.12%		3.66%		0.82%		1.25%		1.12%		24.23%		100.00%			
% of Total 1049 Energy Costs	34.20%		0.25%		6.10%		1.24%		0.70%		0.75%		56.76%		100.00%			
Conversion factors	0.03797		0.03466		0.03668		0.03668		0.04173		0.03982		3.6					

NG = Natural Gas
LFO = Light Fuel Oil
HFO = Heavy Fuel Oil
LPG = Liquified Petroleum Gases

CONSUMPTION OF PURCHASED FUEL & ELECTRICITY - DAIRY INDUSTRIES - ONTARIO - 1992

(Values adjusted by distributing "other fuel" to each fuel type according to initial market share)

SIC	NG		Gasoline		Diesel		LFO		HFO		LPG		Elect		Total	
1041 (Physical amount)	19,109.8	k-cubic metres	3,290.6	kilolitres	8,447.8	kilolitres	7.4	kilolitres	88.8	kilolitres	194.8	kilolitres	159.8	GW.h		
1041 (Dollar Value)	$2.441	million	$1.418	million	$3.681	million	$0.002	million	$0.011	million	$0.072	million	$7.616	million	$15.241	million
1041 (Energy - Terajoules)	725.6	TJ	114.1	TJ	309.9	TJ	0.3	TJ	3.7	TJ	7.8	TJ	575.2	TJ	1,736.5	TJ
% of Total 1041 Energy Use	41.79%		6.57%		17.84%		0.02%		0.21%		0.45%		33.13%		100.00%	
1049 (Physical amount)	49,153.5	k-cubic metres	90.2	kilolitres	2,703.4	kilolitres	605.2	kilolitres	812.6	kilolitres	760.8	kilolitres	182.5	GW.h		
1049 (Dollar Value)	$6.179	million	$0.048	million	$1.103	million	$0.224	million	$0.126	million	$0.136	million	$10.254	million	$18.067	million
1049 (Energy - Terajoules)	1,866.4	TJ	3.1	TJ	99.2	TJ	22.2	TJ	33.9	TJ	30.3	TJ	657.1	TJ	2,712.2	TJ
% of Total 1049 Energy Use	68.81%		0.12%		3.66%		0.82%		1.25%		1.12%		24.23%		100.00%	

APPENDIX C

APPENDIX C: DAIRY PLANT DISCHARGES IN ONTARIO

DAIRY SECTOR (CAN. SIC 1041 - US SIC 2026, CAN. SIC 1049 - US SIC 2021, 2022, 2023, 2024)

DISCHARGER NAME	ADDRESS	MUNICIPALITY	P-CODE	SEWAGE TREATMENT PLANT NAME	TOTAL # OF EMPLOYEES	INDUSTRY PHONE #	INDUSTRY CONTACT	INDUSTRY CONTACT TITLE	INDUSTRY DESCRIPTION	US SIC CODES
COCHRANE'S DAIRY LTD	PO BOX 310	RUSSELL TWP	K0A 3B0	EMBRUN PV LAGOON	00014	613 445-2959			DAIRY (405)	2026
LAURENTIAN VIEW DAIRY LTD	PO BOX 1064	DEEP RIVER	K0J 1P0	DEEP RIVER WPCP	00032	613 584-3777			DAIRY (405)	2026
KAWARTHA DAIRY	GENERAL DELIVERY	BOBCAYGEON	K0M 1A0	BOBCAYGEON WPCP	00030	705 738-5123			DAIRY (405)	2026
WILLIAM NEILSON LTD LTEE	861 CLYDE AVE	OTTAWA	K1Z 5A4	GREEN CREEK WPCP	00098	613 728-1751	W R PARSONS	SENIOR VP	DAIRY (405)	2026
AULT FOODS LTD	453 COOPER ST.	OTTAWA	K2P 0H1	GREEN CREEK WPCP	00163	613 232-4281	W K MCGILLVRAY	GEN MGR	DAIRY (405)	2026
BECKER MILK CO LTD	105 CORNWALL CENTRE ROAD	CORNWALL	K6K 1K6	CORNWALL WPCP	00030	613 932-8530	CLEMENT SABOURIN	GEN MGR	DAIRY (405)	2026
BEATRICE FOODS INC	817 DIVISION ST.	KINGSTON	K7L 4W2	KINGSTON WPCP	00116	613 546-5534	GORDON J SPENCER	GEN MGR	DAIRY (405)	2026
AULT FOODS LTD	108 DAIRY AVE	NAPANEE	K7R 1M6	NAPANEE WPCP	00121	613 354-9751			DAIRY (405)	2026
SMITH'S DAIRY ARNPRIOR LTD	140 DANIEL ST S	ARNPRIOR	K7S 2L7	ARNPRIOR WPCP	00009	613 623-2146			DAIRY (405)	2028
BRUM'S DAIRY LTD	PO BOX 730	PEMBROKE	K8A 6X9	PEMBROKE WPCP	00032	613 735-2325			DAIRY (405)	2026
REID'S DAIRY CO LTD	PO BOX 997	BELLEVILLE	K8N 5B6	BELLEVILLE WPCP	00029	613 968-5100			DAIRY (405)	2026
CHRISTIE'S DAIRY LTD	64 KING ST E	BEAMSVILLE	L0R 1B0	BAKER ROAD WPCP	00047	416 563 8841	W CHRISTIE	MANAGER	DAIRY (405)	2026
BEATRICE FOODS INC	RR 5 461 STEWART RD	NIAGARA-ON-THE-LAK	L0S 1J0	NIAGARA_ON_THE_LAKE	00110	416 641-8151	BOB RUTTAN	GEN MGR	DAIRY (405)	2026
BEATRICE FOODS INC	390 RITSON RD N	OSHAWA	L1G 5R1	HARMONY CREEK NO 1	00160	416 728-6241	ARTHUR M GREENE	GEN MGR	DAIRY (405)	2026
AUGUSTINE'S DAIRY	398 KILLAY ST E	PORT COLBORNE	L3K 1P5	WEST PLANT	00010	416 835-2362			DAIRY (405)	2026
FIELDFRESH FARMS INC	196 SOUTH SERVICE RD W	OAKVILLE	L6K 2H3	SOUTH EAST WPCP	00036	416 844 6205	PETER WERMELS	GEN MGR	DAIRY (405)	2026
FLOWERLEA DAIRY LTD	6 PARK ST	BRAMPTON	L6X 1T8	LAKEVIEW WPCP	00017	416 451-2646	E U GINTHER	GEN MGR	DAIRY (405)	2026
WILLIAM NEILSON LTD LTEE	279 GUELPH ST	HALTON HILLS	L7G 4B3	GEORGETOWN WPCP	00450	416 453-2333			DAIRY (405)	2026
BECKER MILK COMPANY LTD	671 WARDEN AVE.	SCARBOROUGH	M1L 3Z7	HIGHLAND CREEK	00281	416 698-2591			DAIRY (405)	2026
AULT FOODS LTD	1275 LAWRENCE AVE E	NORTH YORK	M3A 3P9	NORTH TORONTO	00325	416 442-2300	R HOCKADAY	SW ONT ZONE MGR	DAIRY (405)	2026
MANDEL'S DAIRY PRODUCTS	29 BALDWIN ST	TORONTO	M5T 1L1	MAIN	00012	416 977-4003			DAIRY (405)	2026
M C DAIRY COMPANY LTD	212 MAVETY ST	TORONTO	M6P 2M2	MAIN	00010	416 766-6711			DAIRY (405)	2026
BEATRICE FOODS	295 THE WEST MALL SUITE 600	ETOBICOKE	M9C 4Z4	HUMBER WPCP	00036	416 626-5500			DAIRY (405)	2026
ASTRO DAIRY PRODUCTS LTD	25 RAKELY CRT	ETOBICOKE	M9C 5G2	HUMBER WPCP	00100	416 622-2811			DAIRY (405)	2026
AULT FOODS LT	405 THE WEST MALL	ETOBICOKE	M9C 5J1	HUMBER WPCP	00100	416 626-3666			DAIRY (405)	2026
NELSON'S DAIRY	180 ORMONT DR	ETOBICOKE	M9L 1N7	HUMBER WPCP	00080	416 742-6811	PETER CALABRETTA	GEN MGR	DAIRY (405)	2026
GAY LEA FOODS CO OPERATIVE	100 CLAYSON RD	ETOBICOKE	M9M 2G7	HUMBER WPCP	00425	416 741-0261			DAIRY (405)	2026
STEEN'S DAIRY LTD	PO BOX 7	ERIN	N0B 1T0	PST	00026	519 833-9663	FRED STEEN	PRES & GEN MGR	DAIRY (405)	2026
LOCAL DAIRY PRODUCTS	7-300 TRILLIUM DR	KITCHENER	N2E 2K6	KITCHENER WPCP	00007	519 748-9836			DAIRY (405)	2026
BEATRICE FOODS INC	PO BOX 1236	KITCHENER	N2G 4G8	KITCHENER WPCP	00175	519 743-1453	BERT LEAR	GEN MGR	DAIRY (405)	2028
BRANT DAIRY CO LTD	364 ELGIN ST	BRANTFORD	N3S 3W2	BRANTFORD WPCP	00042	519 753-4133	G A CAMPBELL	VICE-PRES	DAIRY (405)	2026
WOODSTOCK MILK SPECIALTIES	55-57 INGERSOLL RD	WOODSTOCK	N4S 2R1	WOODSTOCK WPCP	00005	519 537-5343	BRIAN DUIVESTEYN	PRESIDENT	DAIRY (405)	2026
AULT FOODS LTD	75 BATHURST ST	LONDON	N6B 1N8	VAUXHALL WPCP	00150	519 672-9111	NORM R HOBBS	GEN MGR	DAIRY (405)	2026
LAKESIDE JERSEY DAIRY LTD	26 SETTERINGTON ST	LEAMINGTON	N8H 1T2	LEAMINGTON WPCP	00008	519 326-4551	J W LIGHTFOOT	PRES & GEN MGR	DAIRY (405)	2026
AULT FOODS LTD AULT DAIRIES	1501 HOWARD AVE	WINDSOR	N8X 3T5	LITTLE RIVER WPCP	00065	519 253-4606	R E HOCKADAY	SW ONT ZONE MGR	DAIRY (405)	2026
SUNDRIDGE BLUE RIBBON DAIRY	PO BOX 33	SUNDRIDGE	P0A 1Z0	SUNDRIDGE LAGOON	00005	705 384-5377			DAIRY (405)	2026
BELLE VALLEE CREAMERY LTD	PO BOX 480	CASEY TWP	P0J 1A0	BELLE VALLEE LAGOON	00008	705 647-4396			DAIRY (405)	2026
ALGOMA DAIRY OF CHAPLEAU LTD	PO BOX 114	CHAPLEAU TWP	P0M 1K0	CHAPLEAU LAGOON	00008	705 864-0843			DAIRY (405)	2026
FARQUHAR DAIRIES LTD	PO BOX 1689	ESPANOLA	P0P 1C0	ESPANOLA WPCP	00025	705 869-2122	TOM FARQUHAR	GEN MGR	DAIRY (405)	2026
ARCHERS DAIRY LTD	PO BOX 445	KIRKLAND LAKE	P2N 3J1	KIRKLAND LAKE WPCP	00016	705 567-3377	J D ARCHER	PRES & GEN MGR	DAIRY (405)	2026
PALM DAIRIES LTD	PO BOX 2844	SUDBURY	P3A 5J3	SUDBURY WPCP	00040	705 566-2010	GREG CLOSS	BRANCH MGR	DAIRY (405)	2026
BEATRICE FOODS INC	PO BOX 39	SAULT STE. MARIE	P6A 5L2	SAULT STE. MARIE	00043	705 256-5659	R BROCK	NORTH ONT MGR	DAIRY (405)	2026
PALM DAIRIES LTD	PO BOX 338	THUNDER BAY	P7C 4V9	THUNDER BAY WPCP	00068	807 623-8483	RON F FODEY	BRANCH MGR	DAIRY (405)	2026
BEATRICE FOODS INC	134 S WATERLOO ST	THUNDER BAY	P7E 2C3	THUNDER BAY WPCP	00043	807 623-8233	BOB BROCK	GEN MGR	DAIRY (405)	2026
VACATIONLAND DAIRY CO OP	1220 9TH ST N	KENORA	P9N 2T7	KENORA WPCP	00022	807 468-7662	DIANE POCHAILO	MANAGER	DAIRY (405)	2026
STIRLING CREAMERY LTD	PO BOX 117	STIRLING	K0K 3E0	STIRLING LAGOON	00010	613 395-3350			DAIRY (405)	2021
RIVERSIDE CHEESE & BUTTER	PO BOX 627	TRENTON	K8V 5R7	TRENTON WPCP	00045	613 392-6171	N QUICKERT	GEN MGR	DAIRY (405)	2021
SUNDERLAND CREAMERY LTD	RR 3	BROCK TWP	L0C 1H0	BEAVERTON RIVER NO 2	00016	705 357-3124	B BROOKS	PRES & GEN MGR	DAIRY (405)	2021
ALLISTON CREAMERY & DAIRY LTD	PO BOX 460	ALLISTON	L0M 1A0	ALLISTON WPCP	00012	705 435-6751	LLOYD KENNEDY	PRES & GEN MGR	DAIRY (405)	2021
PALMERSTON CREAMERY & DAIRY	PO BOX 10	PALMERSTON	N0G 2P0	PALMERSTON WPCP	00020	519 343-2110			DAIRY (405)	2021
GAY LEA FOODS CO OPERATIVE	21 CLINTON ST	TEESWATER	N0G 2S0	PST	00060	519 392-6865	B KISSNER	GEN MGR	DAIRY (405)	2021
SUNRISE DAIRY	289 JOSEPHINE ST	WINGHAM	N0G 2W0	WINGHAM LAGOON	00016	519 357-1260			DAIRY (405)	2021
AULT FOODS LTD STACEY BROS	PO BOX 519	MITCHELL	N0K 1N0	MITCHELL LAGOON	00150	519 348-8414			DAIRY (405)	2021
SEAFORTH CREAMERY 1981 INC		SEAFORTH	N0K 1W0	SEAFORTH LAGOON	00052	519 527-0610			DAIRY (405)	2021
MEDWAY CREAMERY COMPANY LTD	RR 3	LOBO TWP	N0M 2A0	PST	00007	519 666-1543			DAIRY (405)	2021
GAY LEA FOODS CO OPERATIVE	21 SPEEDVALE W	GUELPH	N1H 6J6	GUELPH WPCP	00069	519 822-5530	N HANSEN	BRANCH MGR	DAIRY (405)	2021
EARLTON CREAMERY LTD	PO BOX 70	ARMSTRONG TWP	P0J 1E0	EARLTON LAGOON	00002	705 563-2380	H FORTIER	PRES & GEN MGR	DAIRY (405)	2021
FARQUHAR DAIRIES LTD	GENERAL DELIVERY	CARNARVON TWP	P0P 1S0	PST	00007	705 377-4919	T I FARQUHAR	GEN MGR	DAIRY (405)	2021
COMMUNITY DAIRY OF KAPUSKASING	37 RIVERSIDE DR	KAPUSKASING	P5N 1A7	KAPUSKASING WPCP	00011	705 335-2405			DAIRY (405)	2021
CHRISTIES DAIRY	4971 KING ST	GRIMSBY		BIGGAR LAGOON						2021

DISCHARGER NAME	ADDRESS	MUNICIPALITY	P CODE	SEWAGE TREATMENT PLANT NAME	TOTAL # OF EMPLOYEES	INDUSTRY PHONE #	INDUSTRY CONTACT	INDUSTRY CONTACT TITLE	INDUSTRY DESCRIPTION	US SIC CODES
ST ALBERT CO OPERATIVE CHEESE	150 ST PAUL ST	ST ALBERT	K0A 3C0	PST	00040	613 987-2872	LEO LEDUC	GEN MGR	DAIRY (405)	2022
KRAFT GENERAL FOODS	PO BOX 220	OSNABRUCK TWP	K0C 1M0	INGLESIDE WPCP	00432	613 537-2226			DAIRY (405)	2022
KRAFT GENERAL FOODS		CHARLOTTENBURGH	K0C 2J0	PST	00062	613 347-2482			DAIRY (405)	2022
J M SCHNEIDER INC	PO BOX 490	WINCHESTER	K0C 2K0	WINCHESTER LAGOON	00136	613 774-2297	VOLKER GRUETZNER	GEN MGR	DAIRY (405)	2022
HYNDMAN CHESSE LTD	GENERAL DELIVERY	EDWARDSBURGH TWP	K0E 1X0	PST	00006	613 989 5760	DENNIS PICHE	GEN MGR	DAIRY (405)	2022
AULT FOODS LTD BALDERSON	GENERAL DELIVERY	DRUMMOND TWP	K0G 1A0	PST	00045	613 267-4805	ROY MCDANNOLD	GEN MGR	DAIRY (405)	2022
FORFAR DAIRY LTD	RR 1	BASTARD & S BURGES	K0G 1V0	PST	00008	613 272-2107	HOWARD FRENCH	MANAGER	DAIRY (405)	2022
MCCAIN REFRIGERATED FOODS INC	PO BOX 38	PORTLAND TWP	K0H 1V0	PST	00040	613 372 2747	G REID	MANAGER	DAIRY (405)	2022
WILTON CHEESE FACTORY	R R #2	ERNESTOWN TWP	K0H 2H0	ODESSA WPCP	00010	613 386-7314	N BROOKS	GEN MGR	DAIRY (405)	2022
KRAFT GENERAL FOODS	PO BOX 10	WOLFE ISLAND TWP	K0H 2Y0	PST	00008	613 385-2677			DAIRY (405)	2022
CANADA PACKERS INC	BLACK DIAMOND RD	THURLOW TWP	K0K 1K0	PST	00329	613 969 0593	DONALD A BRADD	GEN MGR	DAIRY (405)	2022
ELDORADO CHEESE LTD	GENERAL DELIVERY	ELDORADO	K0K 1Y0	PST	00025	613 473-2973	D MCKINNON	PRES & GEN MGR	DAIRY (405)	2022
IVANHOE CHEESE INC	RR 5	MADOC	K0K 2K0	MADOC LAGOON	00031	613 473-4269			DAIRY (405)	2022
BLACK RIVER CHEESE CO LTD	RR 2	MILFORD	K0K 2P0	PST	00005	613 476-2575			DAIRY (405)	2022
HENRY FOODS INC MAPLE DALE		THURLOW TWP	K0K 2V0	PST	00030	613 477-2454			DAIRY (405)	2022
HAROLD CHEESE MFG CO	RR #3 CONCESSION 8	STIRLING	K0K 3E0	STIRLING LAGOON	00008	613 395-3935	G GORDON BAILEY	PRES & GEN MGR	DAIRY (405)	2022
HENRY FOODS INC/CHEESE DIV	RR 3	STIRLING	K0K 3E0	STIRLING LAGOON	00007	613 395-2183			DAIRY (405)	2022
EMPIRE CHEESE & BUTTER CO OP	RR 5	CAMPBELLFORD	K0L 1L0	CAMPBELLFORD WPCP	00008	705 653 3187			DAIRY (405)	2022
UNION STAR CHEESE FACTORY	R R 3	RENFREW	K7V 3Z6	RENFREW WPCP	00008	613 649-2203	YVES LEROUX	GEN MGR	DAIRY (405)	2022
SILANI SWEET CHEESE LTD	RR 1	KING TWP	L0G 1T0	DUFFIN CREEK WPCP	00018	416 939 2561	LEONARD TALARICO	PRES & GEN MGR	DAIRY (405)	2022
ROMAN CHEESE PRODUCTS LTD	4916 MONTROSE RD S	NIAGARA FALLS	L2H 1K5	STAMFORD WPCP	00037	416 356 2639			DAIRY (405)	2022
NATIONAL CHEESE COMPANY LTD	675 RIVERMEDE ROAD	VAUGHAN	L4K 1B2	KLEINBURG WPCP	00117	416 669 9393	LOUIS LETTIERI	GEN MGR	DAIRY (405)	2022
FERRANTE CHEESE MANUFACTURER	5732 HWY 7, UNIT 23	VAUGHAN	L4L 3A2	KLEINBURG WPCP	00006	416 851-2073			DAIRY (405)	2022
QUALITY CHEESE INC	7600 WESTON RD UNIT 57	VAUGHAN	L4L 8B7	KLEINBURG WPCP	00007	416 856-5656			DAIRY (405)	2022
AGROPUR COOPERATIVE	5972 AMBLER DR	MISSISSAUGA	L4W 2B1	LAKEVIEW WPCP	00027	416 629 0990			DAIRY (405)	2022
A UNITED CHEESE LTD	1611 FINFAR COURT	MISSISSAUGA	L5J 4K1	LAKEVIEW WPCP	00011	416 823 7200			DAIRY (405)	2022
MCCAIN REFRIGERATED FOODS INC	550 SPEERS RD	OAKVILLE	L6K 2G3	SOUTH EAST WPCP	00105	416 845 8951			DAIRY (405)	2022
PLUMROSE INC	33 MELFORD DR	SCARBOROUGH	M1B 2G6	HIGHLAND CREEK	00007	416 298-8770			DAIRY (405)	2022
NEW WORLD CHEESE CO LTD	1875 LESLIE ST UNIT 14	NORTH YORK	M3B 2M5	NORTH TORONTO	00004	416 449 5707			DAIRY (405)	2022
RESEARCH FOODS LTD	77 CHAMPAGNE DR	NORTH YORK	M3J 2C6	NORTH TORONTO	00080	416 635 8434	Y SHARMA	GEN MGR	DAIRY (405)	2022
WESTERN CREAMERY CO	60 BRISBANE ROAD	NORTH YORK	M3J 2K2	NORTH TORONTO	00050	416 661 0580	ROBERT BRISCOE	GEN MGR	DAIRY (405)	2022
QUALITY CHEESE INC	459 ROGERS ROAD	TORONTO	M6M 1A8	MAIN	00007	416 656-6565			DAIRY (405)	2022
INTERNATIONAL CHEESE CO LTD	67 MULOCK AVE	TORONTO	M6N 3C5	MAIN	00014	416 769-3547	F COLLETTI	GEN MGR	DAIRY (405)	2022
A FANTIS OF CANADA LTD	1 BESTOBELL RD	TORONTO	M8W 4H2	MAIN	00005	416 259-7979	NICK VAUSILIOU	GEN MGR	DAIRY (405)	2022
GRANDE CHEESE COMPANY LTD	175 MILVAN DR	ETOBICOKE	M9L 1Z8	HUMBER WPCP	00060	416 740-8847			DAIRY (405)	2022
GAY LEA FOODS CO OPERATIVE	PO BOX 40	WILMOT TWP	N0B 1G0	BADEN WPCP	00065	519 634-5434			DAIRY (405)	2022
OAK GROVE CHEESE FACTORY LTD	PO BOX 820	WILMOT TWP	N0B 2G0	BADEN WPCP	00008	519 662-1212			DAIRY (405)	2022
MCCAIN REFRIGERATED FOODS INC	284 HOPE ST	EAST ZORRA-TAVISTO	N0B 2R0	PST	00065	519 655 2337			DAIRY (405)	2022
BEATRICE FOODS INC	PO BOX 10	SOUTH DUMFRIES TWP	N0E 1N0	ST GEORGE PV WPCP	00095	519 448-1311	J D BLAIR	GEN MGR	DAIRY (405)	2022
ATWOOD CHEESE CO LTD	RR 1	ATWOOD TWP	N0G 1B0	RAINY RIVER LAGOON	00019	519 356-2271	SALVATORE CADEDD	GEN MGR	DAIRY (405)	2022
CANADA PACKERS INC	PO BOX 630	MOUNT FOREST	N0G 2L0	MOUNT FOREST WPCP	00035	519 323-1760			DAIRY (405)	2022
PINE RIVER CHEESE & BUTTER	RR #4	RIPLEY	N0G 2R0	PST	00020	519 395 2638	JIM GARDNER	GEN MGR	DAIRY (405)	2022
BRIGHT CHEESE & BUTTER MFG CO	RR 1	BLANDFORD BLENHEIM	N0J 1B0	PST	00007	519 454-8600	M ALLAN SMITH	GEN MGR	DAIRY (405)	2022
MILLBANK CHEESE & BUTTER	PO BOX 100	MORNINGTON TWP	N0K 1L0	PST	00035	519 595 8787	CLIFF B NEWMAN	GEN MGR	DAIRY (405)	2022
UNIONDALE CHEESE FACTORY INC	RR 1	ZORRA TWP	N0M 2G0	PST	00014	519 349-2860	H DOUGLAS	MANAGER	DAIRY (405)	2022
INGERSOLL CHEESE CO	PO BOX 70	INGERSOLL	N5C 3K1	INGERSOLL OLD WPCP	00037	519 485-1020			DAIRY (405)	2022
MANNINA CHEESE CO LTD	1555 CRAWFORD AVE	WINDSOR	N8X 2A9	LITTLE RIVER WPCP	00010	519 973-7510			DAIRY (405)	2022
AULT FOODS LTD	PO BOX 60	THORNLOE	P0J 1S0	PST	00007	705 647-7441	FRED LAFFIN	MANAGER	DAIRY (405)	2022
SALERNO DAIRY PRODUCTS LIMITED	20 MORLEY ST.	HAMILTON	L8H-3R7	HAMILTON WPCP		416 544-6281	C. MARZARO			2022
NESTLE ENTERPRISES LTD CARNAT	181 BISHOP ST	ALEXANDRIA	K0C 1A0	ALEXANDRIA LAGOON	00125	613 525-2121			DAIRY (405)	2023
MUTUAL PRODUCTS OF CANADA LTD	PO BOX 735	MORRISBURG	K0C 1X0	MORRISBURG WPCP	00030	613 543-2961	V WAGEMANS	PRES & GEN MGR	DAIRY (405)	2023
CHAMPLAIN INDUSTRIES LTD	PO BOX 189	CORNWALL	K6H 5S7	CORNWALL WPCP	00035	613 932 1961			DAIRY (405)	2023
RICH PRODUCTS OF CANADA LTD	PO BOX 1008 STN B	FORT ERIE	L2A 5N8	CRYSTAL BEACH WPCP	00225	416 871-2605			DAIRY (405)	2023
CHAMPLAIN INDUSTRIES LTD	7200 WEST CREDIT AVE	MISSISSAUGA	L5N 5N1	LAKEVIEW WPCP	00020	416 826 0801	DENNIS A CARISSE	GEN MGR	DAIRY (405)	2023
DERRY FOODS LTD	2400 LUCKNOW DR UNIT 33	MISSISSAUGA	L5S 1T9	LAKEVIEW WPCP	00007	416 671 0477			DAIRY (405)	2023
GRENADIER INTERNATIONAL	1881 YONGE ST SUITE 600	TORONTO	M4S 1Y6	MAIN	00006	416 482-7887			DAIRY (405)	2023
HEWITT'S DAIRY LTD	128 KING ST E	HALDIMAND	N0A 1H0	CAYUGA WPCP	00030	416 768-3524			DAIRY (405)	2023
AULT FOODS LTD NEW DUNDEE	63 BENJAMIN ST	NEW DUNDEE	N0B 2E0	PST	00060	519 696-2261			DAIRY (405)	2023
CANADA PACKERS INC CONSUM PRO	94 MARGARET ST	HARRISTON	N0G 1Z0	HARRISTON LAGOON	00110	519 338-3030			DAIRY (405)	2023
CHAMPLAIN INDUSTRIES LTD	PO BOX 39	TARA	N0H 2N0	TARA LAGOON	00015	519 934-2010			DAIRY (405)	2023
DURE FOODS	109 ROY BLVD	BRANTFORD	N3R 7K1	BRANTFORD WPCP	00010	519 753-5504	RUSS MANNEN	GEN MGR	DAIRY (405)	2023
GLENN ARROW PRODUCTS LTD	PO BOX 968	WOODSTOCK	N4S 8A4	WOODSTOCK WPCP	00019	519 537-3461	E F CURRIE	GEN MGR	DAIRY (405)	2023
(AULT FOODS LIMITED)	225 EAST AVE , N	HAMILTON	L8L 5J4	HAMILTON WPCP		416 527-2051	CATHY JANIGA	Q C. MANAGER		2023
PETERSON'S ICE CREAM CO LTD	P O BOX 31	ALMONTE	K0A 1A0	ALMONTE LAGOON	00008	613 256-3390	JACK PETERSON	MANAGER	DAIRY (405)	2024

DISCHARGER NAME	ADDRESS	MUNICIPALITY	P CODE	SEWAGE TREATMENT PLANT NAME	TOTAL # OF EMPLOYEES	INDUSTRY PHONE #	INDUSTRY CONTACT	INDUSTRY CONTACT TITLE	INDUSTRY DESCRIPTION	US SIC CODES
CENTRESIDE DAIRY	61 LORNE ST. N	RENFREW	K7V 1K8	RENFREW WPCP	00020	613 432-2914			DAIRY (405)	2024
SENOK FOOD SERVICES LTD	720 BURNHAMTHORPE RD W UNI	MISSISSAUGA	L5C 3G1	LAKEVIEW WPCP	00050	416 896-8015			DAIRY (405)	2024
EPLETT DAIRIES COMPANY LTD	16 SHAFTSBURY LANE	BRAMPTON	L6T 4G7	LAKEVIEW WPCP	00400	416 791-6100			DAIRY (405)	2024
ST CLAIR ICE CREAM LTD	2857 DANFORTH AVE	TORONTO	M4C 1M2	MAIN	00025	416 694-5811			DAIRY (405)	2024
SICILIAN ICE CREAM COMPANY	712 COLLEGE ST	TORONTO	M6G 1C3	MAIN	00020	416 531 7716			DAIRY (405)	2024
METROPOLITAN ICE CREAM INC	18 MOWAT AVE	TORONTO	M6K 1E8	MAIN	00010	416 532 4411			DAIRY (405)	2024
MAYPOLE PRODUCTS LTD	64 FORDHOUSE BLVD.	TORONTO	M8Z 5X7	MAIN	00018	416 252-5925			DAIRY (405)	2024
CHAPMAN'S ICE CREAM	160 MAIN ST W	MARKDALE	N0C 1H0	MARKDALE LAGOON	00075	519 986-3131			DAIRY (405)	2024
BEATRICE FOODS INC	175 UNION ST	SIMCOE	N3Y 2B1	SIMCOE WPCP	00093	519 426-1673	MICHAEL TAYLOR	GEN MGR	DAIRY (405)	2024
SHAW'S ICE CREAM	RR #4	ST. THOMAS	N5P 3S8	ST. THOMAS WPCP	00011	519 631-2510	MORRIS SHAW	PRES & GEN MGR	DAIRY (405)	2024
AULT FOODS LTD AULT DAIRIES	980 WILTON GROVE RD	LONDON	N6A 1N8	VAUXHALL WPCP	00120	519 686-0182			DAIRY (405)	2024
CLASSIC DESSERTS	100 SECOND AVENUE	NICKEL CENTRE	P0M 1M0	FALCONBRIDGE TOWN	00008	705 694-4792	JOHN CHOLETTE	PRES & GEN MGR	DAIRY (405)	2024
BEATRICE FOODS INC	352 MCINTYRE ST E	NORTH BAY	P1B 1C8	NORTH BAY WPCP	00028	705 472-8880	M SCHNEIDER	BRANCH MGR	DAIRY (405)	2024
SCOLLIES DAIRY LTD	640 WATERLOO ST	THUNDER BAY	P7E 2C5	THUNDER BAY WPCP	00020	807 622-1943			DAIRY (405)	2024
STONEY CREEK DAIRIES LIMITED	135-137 KING ST., E	STONEY CREEK	L8G-1L4	HAMILTON WPCP		416 561 5511	G DAWSON			2024
BASKIN ROBBINS	375 AYLMER	PETERBOROUGH		PETERBOROUGH WPCP						2024

Abstract of database developed by MOEE in early 1990s

APPENDIX D

APPENDIX D: EXAMPLE CASE STUDY

Ministry of Environment and Energy
Industry Conservation Branch
Green Industrial Analysis
and Retrofit Program

The Becker Milk Company Ltd.
Green Industry Analysis
Case Study Report

Document No.: 94-8053-07-00-02
Audit No: GA-002 P.O. A-36631-0

94-8053-07-00.02

March, 1995

WARDROP ENGINEERING INC.
6725 Airport Road, Mississauga, Ontario L4V 1V2
Phone (905) 673-3788 Fax (905) 673-8007

CASE STUDY

TITLE:	Green Industrial Analysis of Becker's Scarborough Dairy
CLIENT INFORMATION:	The Becker Milk Company Ltd. 950 Warden Avenue Scarborough, Ontario M1L 3Z7
SIC NAME:	Food and Beverage
SIC CODE:	1041

SUMMARY

The Becker Milk Company Ltd. operates its main dairy plant in Scarborough, Ontario, a facility representative of many dairy operations in the province. A Green Industry Analysis was conducted at the plant to identify "green" opportunities for the reduction of water use, energy use, effluent and solid wastes generation, and improvement of process efficiencies leading to environmental benefits. The study identified nine major improvement projects, with total potential "green" annual savings of about $440,000 at an aggregate simple payback of 2.4 years. The key projects include:

- Recovery of dilute milk solids from rinse streams;
- Recovery and recycling of phosphorus containing acid-cleaner solutions used for Clean-in-Place operations;

- Use of ultraviolet disinfection in processing areas and other isolation measures to further reduce microbial levels and increase product shelf-life;

- Reduction of water and energy use; and

- Reduction of solid wastes.

A number of these opportunities are potentially applicable to other dairies in Ontario. However, site specific investigations must be carried out in each case. The membrane application for milk solids recovery has special merit in view of its multiple benefits of product recovery, effluent organics reduction, and water recovery.

Key "green" technologies identified as part of this study include:

- Membrane technology for the recovery of valuble milk solids from dilute rinse streams;

- Auxilliary centrifuge to allow the recovery of a significant proportion of the main milk separator discharge;

- Ultraviolet disinfection of air in production areas to reduce bacteria and further enhance product shelf-life;

- Recycle systems to recover and reuse acid cleaning solutions; and

- On-line, real-time monitoring of effluent flow and biological oxygen demand (BOD) to allow for correlation of effluent discharges with plant process activities.

INTRODUCTION

Becker's Scarborough dairy, which produces a range of fluid milk, cream, juices, drinks, ice cream, and frozen novelty products, is representative of many operations in the Ontario dairy sector. A Green Industry Analysis (GIA) study was conducted at the plant during late 1994 and early 1995, under the auspices of the Ontario Ministry of Environment and Energy's Green Industry Analyses and Retrofits (GIAR) program. The Ministry and Becker's together engaged Wardrop Engineering Inc., a Canadian consulting engineering firm on the Ministry's GIAR roster, to undertake the assessment. This case study briefly summarizes the nature of the analyses conducted, the potential opportunities identified and relevance to other businesses in the province.

The study involved the investigation and analysis of plant processes and operations, with the objective of identifying "green" improvement opportunities. Generically, such "green" opportunities can include energy, water, effluent and solid wastes reductions, efficiency improvements, and improvements in the environmental effects of plant operations. This study focused specifically on:

- Analysis of water use and water use reduction.

- Recovery of valuble milk solids from dilute milk rinse streams. During cleaning operations, vessels and lines are first flushed with potable water to wash out any remaining milk. As is common in most dairies, these dilute rinses are now simply dumped out of the process system to drains. In addition to saving product, rinse recovery would also reduce sewer surcharge costs and water use.

- Reduction of phosphorus in the effluent through reduction, replacement, and recovery of phosphorus containing chemicals needed for cleaning operations.

- Efficiency mprovements to the ventilation system in production areas to reduce microbial levels, thereby increasing product shelf life, reducing processing costs, and reducing wastage.

- Solid waste source reductions. These opportunities followed from an audit conducted under Ontario Regulation 102/94, conducted earlier for the site.

- Selected energy improvements. Energy assessments and improvement identification were covered more thoroughly in a previous Energy Analysis conducted in 1991 under the Ministry's Industrial Energy Services Program (IESP).

- Evaluation of technologies applicable to this plant, and to the dairy sector in general.

RESOURCE USE PROFILE

Annual resource use, wastes and effluent at the plant are summarized in Table 1, as follows:

TABLE 1
RESOURCE UTILIZATION AT BECKER'S SCARBOROUGH PLANT

ITEM	ANNUAL QUANTITY	ANNUAL COST
Electricity	10 million kWh	$730,000
Natural Gas	1.0 million m^3	$130,000
Water	200,000 m^3	$150,000
Effluent Volume	220,000 m^3	
Excess Effluent BOD	310,000 kg	$170,000
Solid Wastes:		
Total Generated	1,150 tonnes	
Currently Recycled	590 tonnes (51%)	

The primary raw material used by Becker's is milk. In addition, it uses utilities, including water, natural gas and electrical power, cleaning chemicals to ensure adequate sanitation, and packaging materials for final products. Effluent is currently discharged into the sewer after pH monitoring and adjustment, and a surcharge is paid to the local Municipality for biological oxygen demand (BOD) that exceeds the regulated municipal sanitary sewer limit of 300 mg/L.

GREEN INDUSTRY ANALYSIS METHODOLOGY

The GIA methodology involved a sequence of five steps as outlined in Table 2, as follows:

TABLE 2
GIA METHODOLOGY STEPS

STEP	DESCRIPTION
1.	Collection of data on current inputs that were of direct relevance to the study. This included review of recorded information and monitoring of water use in specific process areas, effluent generation and effluent parameters.
2.	Preparation of a water balance using metered and monitored data. Attempted preparation of BOD balance comparing product losses with effluent data.
3.	Operational analysis of the facility to review water use, sanitation, and other relevant operational procedures.
4.	Identification and development of improvement opportunities (Green Efficiency Opportunities or GEOs).
5.	Detailed evaluation of opportunities, including conceptual design of complex projects, costs and savings estimates, and payback calculations.

GREEN INDUSTRY ANALYSIS FINDINGS

The major findings of the Green Industry Analysis study are as follows:

- Becker's has already shown exemplary environmental leadership in the dairy sector. The innovative returnable/recyclable jug program and other measures have ensured that Becker's already exceeds solid waste reduction targets intended to be achieved in the Province by the year 2000.

- Our operational review showed Becker's staff to be conscientious in their use of water and in waste minimization during product change-overs.

- Our water use analysis showed Becker's to be operating within a typical range for dairy plants. Typical water use for fluid milk dairies is in the range of approximately 1 to 3 Litres of water per Litre of product.

- A complete comprehensive water balance could not be prepared because of the difficulty in metering the flow and duration of a large number of batch operations.

- A key component of our analysis was review of Clean-in-Place (CIP) activities conducted regularly for the different processes in the plant. The CIP systems use approximately 30% of all water consumed, as well as generating dilute milk rinses that are ultimately dumped out of the process to sewer, resulting in effluent BOD.

- A more detailed analysis of CIP activities was conducted for July, 1994, a month involving full ice cream production. CIP rinse volumes were estimated to range from approximately 20,000 to 60,000 Litres per day, with milk solids concentrations ranging from approximately 6 to 10 g/L. The estimates of milk solids losses from CIP rinses were also in reasonable agreement with estimated total plant milk losses, as determined by Becker's production staff.

- An additional major source of BOD to the effluent is the discharge from the milk separator. This unit is used primarily for the skimming of butter fat from milk prior to pasteurization. It also removes undesirable solid sludges from the milk, discharging once to twice per hour. However, it also discharges a significant amount of good milk product with these solids. The discharge from the separator, as in most dairies, is currently directed to sewer.

- A balance of BOD for the plant could not be obtained. The effluent BOD quantities suggest equivalent milk losses that are much higher than actual milk losses at the plant. The differences in the BOD balance could not be entirely reconciled, although a variety of contributing factors were identified.

- Using the results of our analysis, we prepared a Green Model of the facility to be used as a starting point to relate production with "green" costs. This model has the potential to become an important management tool that can help Becker's to maintain an environmental leadership position in the dairy industry.

RECOMMENDED GREEN EFFICIENCY OPPORTUNITIES (GEO)

A total of nine major GEOs were identified and recommended for implementation in the study. These recommended improvement projects will help to reduce water use, recover valuble milk solids from rinse streams, reduce effluent BOD and phosphorus levels, improve product shelf-life and reduce solid wastes. Total annual net savings of about $440,000 have been identified at a simple aggregate payback of about 2.4 years. A number of projects indicate very attractive paybacks and are simple to implement. A brief summary of recommendated opportunities and their benefits are provided in Table 3. A more detailed "List of Recommendations" and an "Aggregate Summary for All Recommendations" are provided in Table 4 and Table 5 respectively, as attached.

TABLE 3
SUMMARY OF RECOMMENDATIONS

GEO PROJECT	BENEFITS
Recovery of Dilute Milk Product Rinses	• Effluent BOD Surcharge Reduction (90%) • Recovery of Valuble Product • Water Use Reduction (5%)
HVAC Bacterial Control Measures	• Increased Product Shelf-Life
HTST Condensate Recovery	• Water Use Reduction (8%) • Associated Energy Use Reduction
Super Sheen Solution Recycle	• Effluent Phosphorus Reduction (25%)
Off-Spec Milk Product to Animal Feed	• Solid Wastes Reduction (26%)
UHT Cooling Water Recovery	• Water Use Reduction (2%) • Associated Energy Use Reduction
U-Pak Flush Flow Reduction	• Water Use Reduction (4%)
Ice Cream Waste to Animal Feed	• Solid Wastes Reduction (41%)
Waste Popsicle Sticks to Off-Site Recycle	• Solid Wastes Reduction (1%)

The opportunities are described in more detail in the following sections.

Dilute Milk Rinse Recovery Using Membrane Technology

The most significant and ambitious project involves the use of membrane technology to concentrate and recover valuble milk solids from dilute rinses. rather than allowing these rinses to be dumped to drains. The objective of this project is to reconcentrate the milk to a high concentration. around 18% solids. so that it can be readily incorporated with other ingredients to prepare ice cream mixes.

Membrane technology has already been used extensively in the dairy industry and has found increasing application. It was selected for this project, because it is the only technology that offers a cost effective solution for simultaneously:

- Recovering milk solids from rinse streams, without the addition of any chemicals or other agents that could adversely impact reuse;

- Reducing effluent organics ultimately discharged to sewer; and

- Recovering high quality permeate water also suitable for reuse.

Membrane technology involves the use of semi-permeable polymeric membrane films to "filter" out soluble molecules from water. The major relevant classes of membranes applicable to rinse recovery are: ultrafiltration (UF); nanofiltration (NF); and reverse osmosis (RO). Selection of the specific membrane depends on the type of molecules to be recovered. A NF membrane is selected as the primary option for dilute rinse recovery. A series of pilot tests were conducted earlier on rinse streams at Becker's plant, confirming the suitability of NF membranes.

The pilot tests showed that NF membranes could provide up to 99% rejection[1] for lactose (milk sugar), and complete rejection of proteins and fats. NF membranes typically have higher permeate flux rates than RO membranes, although individual membrane modules tend to be somewhat more expensive.

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[1] Rejection is the ratio of the quantity of a solid component retained in the concentrate to its total quantity in the feed solution. Rejection of lactose for NF45 membrane was determined using Total Organic Carbon (TOC) analysis during pilot testing to be upwards of 99%.

The dilute milk rinses at the plant would be collected on a daily basis from all the major CIP locations in the plant to a series of sanitary holding tanks. The membrane system would rapidly process all the collected rinses to produce a small quantity of highly concentrated product to be used the next day for ice cream manufacture. Milk rinses would be handled at all times in a food-grade manner, and would be processed using a food-grade membrane system to ensure satisfactory product quality. A large amount of permeate water would also be removed from the rinse streams during the membrane processing. This water would be stored in a tank and reused, displacing fresh water. A number of suitable uses were identified for this water.

In addition to the membranes it is also proposed to include an auxilliary centrifuge in the recovery system. The primary benefit of this unit is that it allows the main milk separator discharge to be included with the milk rinses for reconcentration. By recentrifuging using a smaller auxilliary centrifuge, the undesirable solids in the milk can be removed with a smaller milk volume, resulting in an additional net milk savings. The auxilliary centrifuge has an additional benefit of removing other potentially undesirable solids that could impede the operation of the membrane system.

The probable installed capital cost for the proposed project, including the membrane and associated systems, is approximately $1,000,000. The implementation of this system would potentially save upwards of $430,000 per year in recovered product, reduced surcharges, and reduced net water consumption. The probable annual operating costs of the system are approximately $110,000, including membrane replacement, labour, electricity, chemicals, and maintenance. Based on net savings, the simple payback of the project is approximately 3.2 years.

HVAC Baterial Control Measures

A series of relatively simple measures were proposed to help reduce bacterial levels within the plant and thereby further increase the shelf-life of product and reduce potential wastage. The total cost is less than approximately $30,000, with an estimated simple payback through reduced wastage of less than one year. These measures included the installation of partition walls to better isolate different areas of the plant and the use of ultraviolet (UV) light lamps for active bacterial control.

The application of UV technology for water disinfection is well established. Static UV units have also been selectively used for microbial control of air in food facilities. We recommended a novel installation of three unitary UV units at strategic locations near filling machines within the Milk Production area. These recommended units consist of stainless steel ductwork with two vertically mounted UV lamps in series, water-tight fixtures and a fan to continously recirculate the air in the room past the UV lamps. The objective of these units is to actively ensure that bacterial concentrations near the filling units are always maintained at very low levels.

Water/Energy Reductions

Three recommended projects involve water reductions. Two of the project involve recovering hot water that is currently discharged to drain, steam condensate from the milk pasteurizer system and heated cooling water from the cream sterilization (UHT) system, and have associated energy savings. The third project involves reduction of a flow used for flushing. Together these three projects would reduce total daily water consumption by approximately 13%, saving approximately $31,000 annually with a simple payback of less than one year.

Solid Wastes Reductions

Three of the recommended projects involve solid waste reduction. primarily by removing off-spec or waste products that can be directed to animal feed. and removing wood materials that can readily be recycled by off-site recyclers. Together these three measures would remove approximately 380 tonnes of solid wastes. further reducing solid wastes to landfill by an impressive 68%. with a net annual savings of approximately $13,000.

Recycle of Phosphorus Chemicals

A potential future effluent concern is phosphorus. Effective sanitization at the plant necessitates the use of phorphorus containing cleaners. One of the largest phosphorus contributors is Super Sheen. an acid-cleaner product from Diversey Inc. used to ensure the removal of calcium and other deposits ("milk stone") from the pasteurizer system. Currently. however. this cleaner is used only on a once-through basis. It is proposed to implement a recycle tank of acid solution. which would have fresh cleaner added only as necessary. This system would cost approximately $25.000 and have a simple payback of approximately one year. A reduction in total effluent phorphorus of approximately 25% would be achieved.

GREEN TECHNOLOGIES FOR THE DAIRY SECTOR

A number of green technologies were identified during this study. Five technologies that offer a good potential. are presented in Table 6. Each of these technologies is commercially proven. although the membrane technology application for rinse stream recovery is quite new. Major benefits of the first three technologies include reduction of product loss in the effluent stream and its potential recovery. The fourth improves shelf life and. therefore. will reduce potential product wastage. The fifth is potentially useful in calculating appropriate surcharge costs. and in reducing discharges by providing instantaneous feedback on the impact of various operations.

These technologies will have a significant impact on resource conservation in the dairy industry. Approximately 1.3% of the raw milk on average is lost as "shrinkage" in dairies. Product losses to sewer are a significant proportion of this loss, representing a substantial economic loss to the industry. Total milk use in Ontario in 1993/94 was approximately 2.3 billion Litres. At a price of about 60¢/L to the dairy industry, this represents a potential loss of as much as $18,000,000 per year. Recovery of this product will improve profitability, particularly in the fluid milk business where profit margins are low. In all cases, environmental benefits will be realized, as the lost product will not have to be treated in a waste water treatment plant.

Client: The Becker Milk Co. Ltd. File: 94-8053-07-00 Consultant: Wardrop Engineering Inc. Completion Date: March, 1995

TABLE 4

GREEN INDUSTRY ANALYSIS - LISTING OF RECOMMENDATIONS

			PROJECTED ANNUAL SAVINGS FROM																			
			Energy			Water		Liquid Effluent		Solid Waste		Air Emissions		Raw Materials		Other Savings (Costs)	Net Total Savings	Estimated Capital Cost	Simple Payback	Time Frame	Technologies Identified	Comments/ Linkages
GEO CODE	GEO NO	Green Efficiency Opportunity	Type	Quantity/ Units	$	m**3	$	m**3	$	tonne	$	kg	$	tonne	$	$	$	$	Years			
	4.1	Recovery of Milk Solids from Dilute Rinse Streams				10,300	7,700		153,000						265,400	(113,000)	313,100	1,000,000	3.2	One year	Membrane technology	Reduced effluent BOD surcharge
	4.2	HVAC Improvements for Bacterial Control														44,000	44,000	22,000	0.5	Six months	Ultraviolet disinfection of air	Increased product shelf life
	4.3.1	U Pak Flow Timer				7,800	5,850										5,850	2,000	0.3	One month	Timer with a solenoid valve	
	4.3.2	Hot Water Recovery from UHT Cooling	Natural Gas m**3	25,960	3,800	3,600	2,700										6,500	5,000	0.8	One month	Hot water piping	
	4.3.3	HTST No. 1 Condensates	Natural Gas m**3	145,370	21,300	15,000	11,250										32,550	20,000	0.6	Three months	Repiping condensates	
	4.4.1	Recycle of Off-spec Product								145	7,250						7,250	0	Immediate	Immediate		
	4.4.2	Recycle of Ice Cream Production Waste								230	5,500						5,500	0	Immediate	Immediate		
	4.4.3	Recycle of Popsicle Sticks								5	450						450	0	Immediate	Immediate		
	4.5	Recycle of Supersheen Solution													28,220		28,220	22,000	0.8	Six months	Clean-in place system	Reduction in neutralization and effluent phosphorus
		TOTAL		**171,330**	**25,100**	**36,700**	**27,500**		**153,000**	**380**	**13,200**				**293,620**	**(69,000)**	**443,420**	**1,071,000**	**2.4**			

Aggregate Summary for All Recommendations

Date: March, 1995

File #: GA-002

TABLE 5

For Executive Summary and Case Study

Client: **The Becker Milk Company Ltd.**
Consultant: **Wardrop Engineering Inc.**

Resource or Environmental Media	Unit of Measure-ment	Cost per Unit, $	Existing Annual Consumption or Production	Existing Annual Cost Consumption or Production, $	Projected Annual Reduction	Projected % Reduction	Projected Annual Cost Reduction, $	Comments
Electricity (Energy)	kWh		n/a	n/a		n/a		Focus not on energy
Electricity (Demand)	kW		n/a	n/a		n/a		Focus not on energy
Natural Gas	m**3	$0.15	n/a	n/a	171,330	n/a	$25,100	Focus not on energy
Fuel Oil	L							
Other Energy (Specify)		n/a	n/a	n/a		n/a	n/a	
Water	m**3	$0.75	200,000	$150,000	36,700	18	$27,500	
Liquid Effluent	m**3		220,000		36,700			Savings in surcharge below
Solid Waste	tonnes	$34.74	560	$19,000	380	68	$13,200	
Air Emissions	kg							
Packaging	tonnes							Not part of study scope
Chemicals	kg	$1.63	20,000	$32,600	14,000	70	$22,800	
Sewer Surcharge	$/year			$170,000		90	$153,000	Surcharge for BOD
Raw Materials	$						$265,400	Reuse of recovered product
Neutralizing caustic	kg	$0.61	67,200	$40,992	8,700	13	$5,420	
Processing costs	$						$44,000	Proj 4.2 - improved ventilation
Column Totals				**$412,592**			**$556,420**	

Additional Annual Savings:	
Additional Annual Costs:	$113,000
Net Annual Cost Reduction:	**$443,420**
Total Projected Capital Investment:	**$1,071,000**

Direct Jobs Created: 1 person year

Other Jobs Created: 5 person years including the multiplier

Technology Identified
Membrane concentration for rinse recovery
UV disinfection of air
Auxiliary centrifuge for discharge milk minimization
CIP system for acids reuse and recycling
Metering and controls for water reduction

A:\GIATOTAL

TABLE 6
GREEN TECHNOLOGIES FOR THE DAIRY SECTOR

TECHNOLOGY	TECH. STATUS	COMMERCIAL STATUS	BENEFITS	BARRIERS TO COMMER APPL	IMPLEMENT STRATEGY	IMPACT ON RES. CONSER.
Membrane Conc. to Recover Milk Solids	Developed Technology	Not commercialized for this purpose.	Recover product, reduce effluent loading, recover water	Lack of experience in this application	Becker's is a good location to start implementation because of good payback	Product recovery of milk lost with CIP rinses. Reduction in BOD load to treatment plants
Optical Turbidity Meter	Developed	Yes, but not fully accepted in dairies	Reduce the use of water for rinse operation	Should be reviewed under Agriculture Canada's DPRIS requirement	Demonstration and distribution of info required	Water use and effluent reduction
Auxilliary Centrifuge for Main Milk Separator Discharge	Developed	Commercialized, but not widely used	Net milk recovery	Technical. Dilute recovered milk must have appropriate use available.	Implementation enhances payback of membrane project.	Product recovery of milk lost from separator discharge. Reduction in BOD load to treatment plant
Ultraviolet Disinfection to purify air	Developed	Accepted by the industry	Increase product shelf life	No barriers	Can be applied as needed	Reduction in water, energy and waste generation during reprocessing
CIP systems to recover acid for milk stone clean out	Developed	Commercialized	Reduce effluent phosphorus and chemical costs for cleaning and neutralization	No barriers except costs		Significant reduction in cleaning chemicals and in treatment costs.
On-line, real time effluent monitoring and linkage with process	Developed but expensive	BOD monitoring system is commercialized. Flow integration is possible	Reduction of water use, avoidance of violations Reduction of organic discharges	Cost of an integrated system will be $100,000	Costs will have to be reduced.	Reduction of product loss and organic loads on municipal system

APPENDIX E

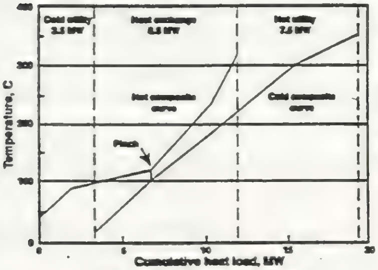
APPENDIX E

Background On Energy Process Integration Analysis

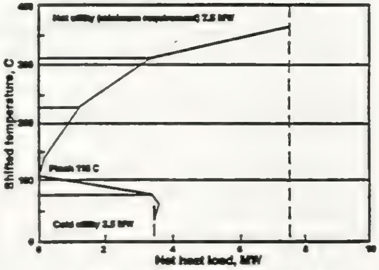
ENERGY PROCESS INTEGRATION (PINCH)

Energy Process Integration analysis involves the following sequential steps:

- Formulation of mass and heat balances to describe processes.
- Logical organization of the energy flows in these processes to identify all cold streams that require heating, and all hot streams that require cooling.
- Graphical construction on temperature-enthalpy diagrams of the Composite and Grand Composite Curves, as shown below, to illustrate the summary energy flows for all processes analyzed. Wardrop employs a specialized proprietary software package for this task.
- Identification from the curves of the minimum energy use targets for the hot utilities (e.g., steam) and cold utilities (e.g., cooling water and refrigeration). These targets, which are thermodynamically feasible minimums, allow plant management to assess present energy efficiency, and to establish, with confidence, specific goals to reduce energy costs. The curves also define the PINCH, or the closest overall temperature approach, which has special significance in determining appropriate heat exchange.
- Reorganization of a heat recovery network, based on a simple set of systematic rules, to improve efficiency and to avoid costly inappropriate heat exchanges that may exist. The PINCH approach also prioritizes the heat recovery opportunities for future planning. Identified efficiency improvements can be undertaken with the confidence that they are globally beneficial, without hidden energy costs elsewhere in the plant.
- Modification, as necessary, of utilities to better suit the requirement of the processes. Inappropriate or unnecessary utilities can be restructured or eliminated to reduce costs. Appropriate opportunities for cogeneration can also be identified.



COMPOSITE CURVES



GRAND COMPOSITE CURVE

Energy Process Integration is flexible, and can be applied effectively to an entire complex, to selected areas, or even to individual processes. The procedure allows for evaluation of new process designs, auditing of the energy efficiency of existing operations, and decision support in review of process modifications.

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Shell UK Ltd	Oil refinery	RD/19/26
Tioxide Plc	Titanium dioxide manufacturer	RD/6/13
Proctor and Gamble Ltd	Soap and detergent manufacturer	RD/8/19
Staveley Chemicals	Production of organic chemicals	RD/30/31
William Blythe Ltd	Production of inorganic chemicals	RD/5/20
Cray Valley Products Ltd	Production of synthetic resins	RD/13/15
Beecham Pharmaceuticals	Solvent recovery unit	RD/16/17
Long John International	Grain whisky distillery	RD/4/9
Tetley Walker Ltd	Brewing	RD/11/22
Cadbury Typhoo Ltd	Milk and beverage powder manufacturers	RD/12/23
Express Foods	Creamery	RD/22/29
Van den Berghs and Jurgens	Edible oil refining	RD/14/14
J Lyons & Co Ltd	Food processors	RD/20/27
East Lancashire Paper Mill	Paper manufacturer	RD/15/18
St Regis International	Paper manufacturer	RD/17/16
Sheerness Steel	Steel Works	RD/18/25
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Coalite Fuels Ltd.	Coalite Fuels & Chemicals Process Integration Study - A Summary	RD/037
British Steel	Cost Reductions on an Integrated Steel Plant	RD/050
May & Baker Ltd.	Speciality Chemicals Plant Process Integration Study - A Summary	RD/051
May & Baker Ltd.	Cost Reduction on Speciality Chemicals	RD/059
Batchelors Foods Ltd.	Cost Reductions on Processed Food Plant	RD/061

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APPENDIX F

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Potential BOD Imbalance for Fluid Milk Plants

A potential problem exists with regard to the reconciliation of BOD generation with actual losses at fluid milk plants, especially given that most such plants discharge to municipal systems with charges according to monitored BOD levels. Based on the above cited typical generation factor of 3 kg BOD per 1000 kg milk and the relationship between BOD and milk quantity, an equivalent loss of approximately 30 Litres of milk per 1,000 Litres or 3% can be derived for Fluid milk plants.

This milk loss is 2 to 3 times higher than actual losses experienced. A general rule of thumb is that fluid milk plants with good operating practices can expect losses of approximately 1.5% of product, with :

- 0.75% of product volume lost within the plant as a result of processing; and
- 0.75% of product volume as returns.

Specific data on milk "shrinkage" for fluid milk plants in Ontario over the period from 1981 to 1992 shows an average shrinkage of approximately 1.3%.[1] Shrinkage involves a reconciliation by plants of received raw milk with output, and includes not just losses to effluent.

A significant potential discrepancy between actual milk losses and that predicted by typically cited effluent BOD quantities. The result may be that dairy processing plants may be overcharged in terms of BOD relative to the actual losses that would represent the major source of BOD.

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[1] Data as provided by the Ontario Dairy Council. 1995.

This potential inconsistency has not been fully investigated and no clear explanation exists.[2] Available data was reviewed and a number of plants were contacted. In several cases a BOD inconsistency was qualitatively or quantitatively indicated. Some fluid milk plants did, however, indicate a relative balance between BOD and milk losses. Further investigation of this potential imbalance is warrant.

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[2] There are a number of potential explanations, none of which can fully explain the discrepancy. One is that the 3 kg BOD coefficient value is based on older effluent data where losses may have been 3%. However, shrinkage data for Ontario as far back as 1981, shows shrinkage of no more than approximately 1.6%.